MAY 29 1925

ENGINEERING:

An Illustrated Weekly Journal.

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VOL. CXIX.—No. 3098.] LONDON: FRIDAY, MAY 15, 1925. [Registered at the General Post Office as a Newspaper.] [PRICE ... 1s. BY INLAND POST 1s. 2½d.

Aveling & Porter, Ltd.,
ROCHESTER.
Steam & Crude Oil Road Rollers, &c.
2581

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CULVER STREET WORKS, COLCHESTER.
On Admiralty and War Office Lists.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 87.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2.
See half-page Advert. last week and next week. 2781

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell. 2691

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Thos. Piggott & Co., Limited,
BIRMINGHAM. 2530
See Advertisement last week, page 13.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page 38, May 8.* 1994
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 2572

Brett's Patent Lifter Co.
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Hammers, Presses, Furnaces,
COVENTRY. 610

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W.11.
Est. 1854. 2703

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CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c
Chief Offices: 129, Trongate, Glasgow. Od 8547
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Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C.3. 1834

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Ingot Iron Tubes. 2267
The Scottish Tube Co., Ltd.
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 33, May 8.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS
SHALLOW DRAFT VESSELS.
2276

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam
Bevel and Mitre Wheels planed up to 6 ft. 6 in. diam.
Spur Wheels cut up to 12 ft. 6 in. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD.,
PORTSMOUTH,
SHIP & LAUNCH BUILDERS, Od 3351
ENGINEERS & BOILER MAKERS.

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS. Od3382
Reg. Office and Chief Works: Motherwell. London Office: 32, Great St. Helen's, Bishopgate, E.C.3.

OIL FUEL APPLIANCES,
Systems
PRESSURE AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
Telephone No.: Central 2832.
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Gearing of all Descriptions.
GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 28 ft. diameter.
BRICK and CLAYWORKING MACHINERY of all kinds.
ENGINES:—"Uniflow," "Corliss," or Drop Valve.
CLAYTON, GOODFELLOW & CO., LTD.
Blackburn. 2653

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THE GLASGOW ROLLING STOCK AND PLANT WORKS,
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E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1794

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 2633

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AND PROPULSION PROBLEMS.
Special designs only.
"Circulation Theory."
Akimoff Propeller Company,
PHILADELPHIA, U.S.A. 2349

R. Y. Pickering & Co., Ltd.
(Established 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEELS and AXLES of all kinds.
Chief Offices and Works:
WISHAW, SCOTLAND.
London Office: Od 8353
10, IDDESLEIGH HOUSE, WESTMINSTER, S.W.1.

John Bellamy Limited
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.

STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 53. 2584

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 2858
See Advertisement, page 51, May 8.

New Wire Ropes,
Half price. Send for list.
LONDON ELECTRIC FIRM.
Croydon. 2722

BARGAINS FROM BOLTON.
300/325 I.H.P. Corliss VALVE CROSS COMPOUND CONDENSING ENGINES, by The Burnley Ironworks, Ltd.
Belt flywheels 16 ft. diameter by 26 in. wide. Corliss valves to inlet and exhaust of both cylinders. Vertical Air Pump and Condenser below floor level, worked by L crank from L.P. crosshead.
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THOMAS MITCHELL & SONS, LTD., Edgar Street, BOLTON. 2811
Telephone: 302 (Three lines). Telegrams: "REALIZE."

TRADE "SUMMIT" MARK.
Slitting Saws
AND SCREW SLOTTING CUTTERS.
JOSEPH THOMPSON (Sheffield) LTD.,
Townhead Street Engineering Works,
SHEFFIELD. 2677

New 300 & 500 B.HP. M.A.N. STATIONARY DIESEL ENGINES with accessories, as delivered from the makers under Peace Treaty; also Dynamos for same. All spare parts in stock.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Victoria Street, E.C. 4. 2527

Belliss Three-crank Compound ENGINES, 500 Kw., Dynamos 230 Volts, D.C. Also Brush-Parsons 600 Kw. EXHAUST TURBINE SET 230 Volt, D.C., with complete condensing plant. Very low price.
JENNINGS, 2402
West Walls,
Newcastle-on-Tyne.

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ELECTRICAL
INSULATING FABRICS
AND TAPES.
Manufactured solely by—
M. BARR & CO., LTD.,
83 Hutcheson Street, Glasgow.

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ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES } Row's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS.
2277

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS Dumbarton. 2212
See Full Page Advt., page 65, April 24.

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 62, April 24. 8195

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 58. 2402

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED
DARLINGTON. 2702

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS,
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
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LIMITED.
Works and Offices: 120, Cornwall Street, Glasgow.
Branch Office: 4, Albert Square, Manchester.
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Adjustable Taper Roller Bearings. 2698

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Branch Office and Depot: 14, SNOW HILL, BIRMINGHAM. 'Phone: Central 2775.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters. Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers, &c., &c. 2327

Component Parts, Small Gearings, etc. Estimates given.—SPARK'S ENGINEERING WORKS, 283-287 King Street, Aberdeen. H 351

Telegrams: "Ilpa," London.
Telephone: 7424 Central.
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CHARTERED PATENT AGENTS,
306, High Holborn, London, W.C.1. 585
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The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2701

Norton&Gregory Engineering SCHOLARSHIPS 1925

The following Scholarships, total value £450, have now been awarded:—
ARTHER AYLWIN FLETCHER-JONES, Monkton Combe School, Nr. Bath; £100 per annum tenable for 3 years at Cambridge University.
RICHARD PETER ALSTON, Clifton College; £50 per annum tenable for 3 years at Cambridge University J 50

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech., London Univ. (Matric., Inter., B.Sc.), Inst.M. & Cy.E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc.M.Inst.C.E., Chartered Civil Engineer. M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 2689

Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2863

TENDERS.

HONG KONG WATERWORKS.

SHING MUN SCHEME.

PRELIMINARY NOTICE.

THE CROWN AGENTS FOR THE COLONIES will shortly be prepared to consider

Tenders from Approved

FIRMS, for the CONSTRUCTION of the Pipe Connecting Mains across Hong Kong Harbour, between Victoria and Kowloon.

Preliminary particulars as to the general requirements of the proposed works may be obtained at the Office of the Consulting Engineer, Mr. WILLIAM FAIRLEY, M.Inst.C.E., Parliament Mansions, Victoria Street, Westminster, S.W.1, as it will be necessary for Firms wishing to tender to obtain certain local information. Appointments must be previously arranged. J 32

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 3rd June,

Tenders for the Supply of:—

1. BALLAST WAGONS;

and up to Noon on Wednesday, 27th May, TENDERS for the SUPPLY of:—

2. WHEELS AND AXLES FOR CARRIAGES (SORBITIC TYRES);
3. WHEELS AND AXLES FOR WAGONS;
4. PHOSPHOR TIN.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 20s. each for Nos. 1, 2 and 3, and 10s. for No. 4 (which will not be returned).

The Directors do not bind themseves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices; 91, Petty France, Westminster, S.W.1.
11th May, 1925. J 17

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for Five 10-Ton Hand TRAVELLING CRANES.

Specification and form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 14th May, 1925.

A fee of 20s. will be charged for the Specification, which is NOT returnable.

Tenders must be submitted not later than Noon, on Tuesday, 26th May, 1925.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By order of the Board,
R. C. VOLKERS,
Secretary. J 66

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:— PAINTS, ETC., AND VARNISHES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Paints, etc.," must be left with the undersigned not later than Twelve Noon on Friday, the 29th May, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of the Specification.

A. MUIRHEAD,
Managing Director.

91, Petty France, Westminster, S.W.1
12th May, 1925. J 56

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

Tenders for:—

1. BEARING PLATES FOR RAILS.
2. 25-TON HAND POWER BREAKDOWN CRANE.

Tenders due on the 26th May, 1925, for No. 1, and on the 28th May, 1925, for No. 2.
Tender forms obtainable from above. J 49

COUNTY BOROUGH OF DARLINGTON WATER WORKS.

ELECTRICALLY DRIVEN PUMPING PLANT.

The Corporation of Darlington invite

Tenders for Supplying and

ERECTING at the Darlington Water Works, SIX ELECTRICALLY DRIVEN CENTRIFUGAL or TURBINE PUMPS, of capacities 4000 (No. 3) 2000 and (No. 2) 1000 gallons per minute respectively.

Full particulars of the plant and conditions of contract may be obtained from Mr. ERNEST MINORS, B.Sc., A.M.Inst.C.E., Water Works Engineer, Town Hall, Darlington.

Sealed Tenders endorsed "Tender for Electric Pumps" must be delivered not later than Twelve o'clock noon on Friday, 29th May, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

H. HOPKINS,
Town Clerk.

Town Clerk's Office, Houndgate, Darlington. J 11

CORPORATION OF GLASGOW.

TRAMWAYS DEPARTMENT.

Sub-station Plant for Sale.

The Tramways Department of the Corporation of Glasgow, are prepared to receive

Offers for the undernoted

PLANT, which can be seen at Coplawhill Sub-station, 522, Pollokshaws Road, Glasgow, S.S.

The Plant was supplied and installed in Paisley by the British Westinghouse Electrical Co. (now Metropolitan-Vickers Electrical Co.) in 1920, and passed to this Department from Paisley Burgh at the recent acquisition of the Paisley Tramways.

2 Rotary Converters, 500 Kw. Compound wound with compoles, 6 phase, 6 pole, 50 periods=1000 Revs., 550/600 volts, 910/835 amps. (Serial Nos. 642191 and 642195), complete with Starting Motor, Three-phase Oil-immersed Transformers, Oil Break Switches, Starting Panels, and D.C. Panels.

Specifications of the Plant, Conditions of Sale and further particulars can be obtained on application to Mr. JAMES DALRYMPLE, General Manager, 46, Bath Street, Glasgow. Sealed Offers, marked outside "Tramways—Tender for Sub-station Plant for Sale," must be lodged with the Subscriber on or before Tuesday, 26th inst., at Ten a.m.

The highest or any offer may not be accepted.

J. LINDSAY,
Town Clerk.

City Chambers, Glasgow.
5th May, 1925. H 980

GREAT SOUTHERN RAILWAYS (IRELAND).

CONTRACTS, 1925.

The Directors of the Great Southern Railways Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES for Six Months commencing 1st July, 1925, and alternatively for twelve months commencing the same date.

	No. of Form.		No. of Form.
Acid, Sulphuric ...	3D	Hardware Brass and Iron	17
Asbestos Sheeting, etc.	40	India Rubber Goods	9A
Baskets	10	Implements, Sundry	21
Bolts, Nuts and Rivets	15	Iron Tubes and Fittings	29
Brooms and Brushes	13	Leather and Leather Goods	12
Brass Fittings for Carriages... ...	18	Locks and Keys ...	19
Do. do. for Water	26A	Mantles for Gas ...	26C
Do. do. for Gas ...	26B	Mats, Fibre	10
Canvas and Sacks ...	6	Nails	31
Castings, Mall. Iron	11	Nuts, Hex, Black and Bright... ...	15A
Carriage Laces ...	7A	Packings	40
Cloth for Carriages	7C	Plumbago	41
Clothing, I.R. proofed	9B	Rain Water Pipes and Gutters	25
Coach Screws and Washers	15	Ropes, Twine & Flax	4
Colours	2	Soaps	3C
Corks	39	Sewer Pipes, Plaster of Paris, etc. ...	32
Cotton Waste ...	5A	Shovels, Spades, etc.	21A
Crucibles	41	Sponge Cloths ...	5
Drysalteries	3	Signal Wire Pulleys	11
Emery and Glass Cloth, etc.	28	Screws and Split Pins	14
Files and Tool Steel	20	Sheet Tubes	29
Fire Bricks and Clay	33	Tin Plates	22
Foundry Requisites	42	Waste	5A
Galvanized Sheets, Buckets, etc. ...	23	Waterproof Clothing	9B
Grates, Stoves ...	24	Wicks	5
Grindstones	28	Wire, Fence and Signal	30A
Glass, Sheet, and Plate	27A	Wirework	30B
Glass and China Sundries	27B		

Forms of Tender can be obtained on PAYMENT of 6d. each from the STORES SUPERINTENDENT, GENERAL STORES DEPARTMENT, G. S. Rys. INCHICORE, DUBLIN. Applications for forms by Post must be accompanied by Postal Order. STAMPS CANNOT BE ACCEPTED. All enquiries for information should be also directed to the Stores Superintendent.

Patterns may be inspected at the General Stores Department, Inchicore, on and after the 18th inst., between the hours of Ten a.m. and Four p.m. (except on Saturdays).

Tenders must be enclosed in the special envelope supplied for the purpose with each schedule, and must be posted so as to be with the undersigned before Ten a.m., on Thursday, 4th June, 1925.

The Directors will not consider any Tender unless it is furnished on the Company's Form, and do not bind themselves to accept the lowest or any Tender.

By Order,
C. E. RILEY, Secretary.

Kingsbridge Terminus, Dublin, May, 1925. J 60

CITY OF LIVERPOOL.

The Corporation are prepared to receive

Tenders for the Supply and

DELIVERY of various classes of TRAMWAY MATERIAL, as under:—

Schedule No. 1.—Steel Tramway Rails.
Schedule No. 2.—Steel Tramway Rail Fishplates.
Schedule No. 3.—Steel Fishbolts.
Schedule No. 4.—Steel Tiebars.
Schedule No. 5.—Copper Bonds.

Firms are required to state clearly, when making application for the necessary Tender Forms, the name and number of the schedule for which they desire to be furnished with Tender Form.

Duplicate Forms of Tender for record purposes will NOT be supplied.

Tender Forms will be forwarded upon receipt of application in writing to:—

THE CITY ENGINEER,
Municipal Buildings, Dale Street, Liverpool.

Tenders must be sealed and enclosed in the official envelopes provided, endorsed in accordance with the instructions given on the Form of Tender, and forwarded through the post addressed to:—

THE TOWN CLERK,
Municipal Buildings, Liverpool.

Latest time and date for receipt of Tenders:—Ten o'clock a.m., on Friday, the 22nd May, 1925.

WALTER MOON,
Town Clerk.

29th April, 1925. H 983

PORT OF BRISTOL.

20,000 TON SILO GRANARY, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee are prepared to receive

Tenders for the Construction

of a FERRO-CONCRETE built SILO GRANARY of 20,000 tons capacity, carried on Ferro-Concrete piles.

On and after Friday, the 15th day of May, 1925, copies of the specification and contract drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol. *All cheques must be made payable to the Bristol Docks Committee.* The deposit of £5 will be returned to all *bona fide* Tenderers after the receipt of a Tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope endorsed, "Tender for Granary," addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings before Ten a.m., on Monday, the 15th day of June, 1925.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PRACE,
Chief Engineer,
Port of Bristol.

Chief Engineer's Office, Avonmouth Docks.
8th May, 1925. H 962

COUNTY BOROUGH OF BLACKBURN.

ELECTRICITY DEPARTMENT.

The Electricity Committee have

For Immediate Disposal and

REMOVAL the following PLANT now lying at their Jubilee Street Distribution Station, which can be inspected at any time.

Lot 1.—Two Westinghouse 2000 Kw. TURBO ALTERNATORS, 6600 volts, 50 cycles, 3000 r.p.m., complete with exciters, condensers, electrically driven extraction and air pumps.

Lot 2.—One Westinghouse 400 Kw. D.C. MOTOR GENERATOR, complete with starting and control panel, 440-550 volts and vice versa.

Lot 3.—Seven LANCASHIRE BOILERS, 33 ft. 0 in. by 8 ft. 6 in., 185 lbs. pressure, fitted with Proctor's Stokers and McPhail's Superheaters.

Lot 4.—One Rees Roturbo CIRCULATING PUMP, capacity 200,000 gallons per hour. Head 72 ft., complete with 93 HP., 440v. D.C., motor and starting gear, spare armature and field coil.

Lot 5.—One Rees Roturbo CIRCULATING PUMP, capacity 100,000 gallons per hour. Head 50 ft., complete with 38 HP., 440v. D.C., motor and starting gear, spare armature and field coil.

Lot 6.—Two Ralls Compound long stroke FEED PUMPS, 5,000 gallons per hour.

Lot 7.—One Weir Centrifugal Steam Turbine Driven FEED PUMP, 10,000 gallons per hour against 185 lbs. per square inch.

Lot 8.—One Westinghouse Rees Roturbo Steam Turbine Driven Pump, 7500 gallons per hour against 185 lbs. per square inch.

Lot 9.—One Hart's Wet AIR FILTER complete with motor suitable for 2000 Kw. alternator.

Lot 10.—One Wright Water PURIFYING PLANT with quartz sand filters, capacity 8000 gallons per hour.

Lot 11.—One Bruce Peebles 300 HP. shunt wound MOTOR, 440v. 240-312 revs. per minute with liquid starter and control panel.

Lot 12.—One Bradford COOLING TOWER, capacity 200,000 gallons per hour (Davenport Engineering Company).

Lot 13.—Two B.C.C. 95 HP. D.C. MOTORS, 440v., 430 revs., with starters.

The Corporation are open to consider offers for the above plant.

The highest or any Tender will not necessarily be accepted

Tender Forms and particulars can be obtained from

P. P. WHEELWRIGHT, M.I.E.E.,
Engineer and Manager,
Corporation Electricity Works,
Jubilee Street,
12th May, 1925. Blackburn. J 59

APPOINTMENTS OPEN.

Required by an old established

Engineering Firm producing light agricultural machinery, and employing about 400 men, a GENERAL MANAGER to take entire charge. Replies should give full particulars of experience with references, and should state salary required.—Address, J 5, Offices of ENGINEERING.

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.

Principal: CHARLES COLES, B.Sc. (Lond.).

The Services will be Required

in September next, of TWO Full-time ASSISTANT LECTURERS in Engineering, qualified in each case to teach up to Honours B.Sc. standard. The main subjects required will be those of Mechanical and Civil Engineering, but a good knowledge of Electrical Engineering will be a recommendation.

SALARY SCALE: £300—15—450 per annum, with such variation in the scale as may be necessary by the application to Cardiff of the Burnham Award.

Applications on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three recent testimonials, should reach the Principal (from whom further particulars may be obtained) on or before Saturday, 30th May.

The successful candidates will be required to pass a Medical Examination by the Authority's Medical Examiner for Teachers, at Cardiff, before commencing duties, and to contribute under the Local Pensions Scheme, if not accepted under the School Teachers (Superannuation) Acts.

JOHN J. JACKSON,
Director of Education,
City Hall, Cardiff. J 39

Gentleman,

with good practical experience in centrifugal pipes casting process (spun or sand pipes)

WANTED

by Important Continental Foundry.

Apply by letter, giving full particulars of experience, age, and wage required:—

Address, J 10,
Offices of ENGINEERING.

Quantity Surveyor

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THE LITTLETON RESERVOIR OF THE METROPOLITAN WATER BOARD.

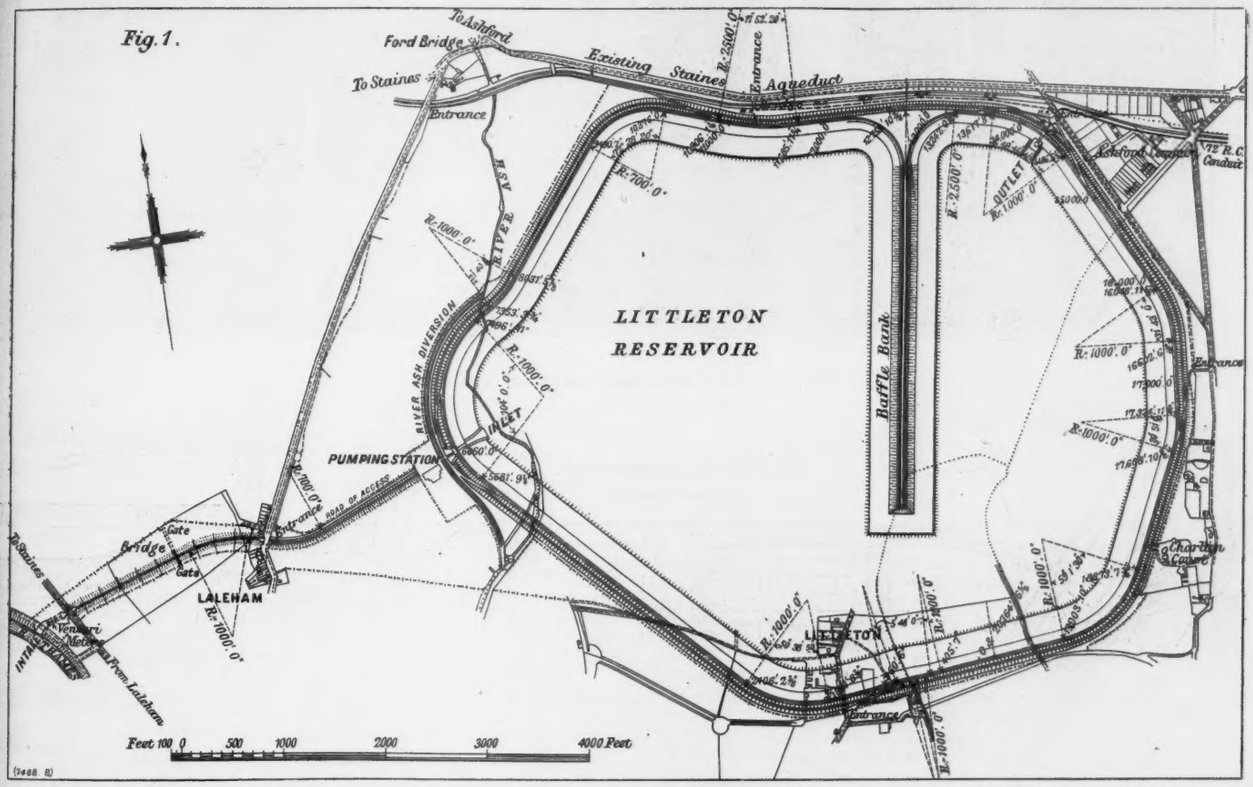
THE inauguration of the Littleton Reservoir by His Majesty the King, on June 13, will mark an important stage in the great scheme of works undertaken by the Metropolitan Water Board in order to secure an ample supply of pure water for London. The site for the new storage reservoir which has a water surface of about 723 acres and is capable of holding some 6,750,000,000 gallons, was selected as far back as 1911, when the Bill for the works was promoted. Work was actually commenced in 1914 and was continued somewhat spasmodically for about eighteen months, progress being, of course, delayed by the war, so that it was eventually completely suspended in February, 1916. A resumption was made in 1919, when a fresh contract for the constructional work was let to Messrs. S. Pearson and Son, Limited, and on the successful completion of what, we believe, is the largest artificial reservoir in the world, the Board's chief engineer, Mr. Henry E. Stilgoe, M.Inst.C.E., and his staff must be congratulated, as also must be the contracting firms who have carried out various parts of the work.

We have already illustrated and described the design and construction of the reservoir itself, and of the intake and outlet works, in considerable detail, in ENGINEERING, vol. cxiv, on pages 481 and 689, to which we must refer our readers for a general description, but before dealing with the later part of the work, as we now propose to do with the aid of further drawings, photographs and particulars kindly placed at our disposal by Mr. Stilgoe, it may be desirable to repeat some of the information previously given as to the location of the reservoir and its design. The reservoir, a plan of which is given in Fig. 1, is an irregular seven-sided polygon with rounded corners, and is located north of the Thames between Staines and Shepperton, its centre being about 2½ miles south-east of the former. Water is drawn from the river just below Penton Hook lock, and, after passing through Venturi meters, is conveyed by means of an open channel, some ¾ mile in length, to a steam-power pumping station, situated close to the western end of the reservoir, and there pumped over the embankment through steel pipes. The main embankments are about 38 ft. in height above the average ground level, the depth of water, when the reservoir is completely filled, being about 38 ft. At this depth, it should be explained, the water level will be about 6 ft. below the top of the embankment, the normal ground level having been reduced to this extent by excavation over the whole of the site. The embankments are composed of earth with a clay-puddle core carried down and keyed into the London clay, the sides being formed to a 3 to 1 slope on the water face and to a 2½ to 1 slope externally. The outer face is covered with soil and loam 3 ft. in thickness, in which shrubs, &c., will be planted. Protection of the water face of the embankment is provided by 6-in. concrete slabs for the lower part and by concrete-block pitching for the upper part, the pitching being finished at its upper edge by a concrete coping formed with a concave face to throw back the waves. In addition to the main embankments, a baffle bank 4,000 ft. in length and extending inwards from the northern side has been constructed in the reservoir to promote the circulation of the water passing from the inlet to the outlet, and also to reduce the height of surface waves formed by the wind. This bank, which is also constructed of earth, but without a puddle core, has been formed with a slope of 4 to 1 on both sides for the lower portion and with a slope of 3 to 1 for the upper portion, which is protected from erosion by concrete-block pitching.

The outlet works are situated at the north-eastern corner of the reservoir, near Ashford Common, as indicated in Fig. 1, and comprise an octagonal concrete shaft, constructed on the bed of the reservoir 136 ft. 6 in. from the centre line of the embankment. It is provided with six single-face sluices at different levels, the water entering through these sluices flowing through a tunnel constructed of cast-iron segments, lined with brickwork and concrete, to a second shaft constructed in the embankment outside the puddle core. Rising in this shaft, the water flows out through two ferro-concrete conduits 8 ft. in diameter, the inlets to which are controlled by single-face sluices. A 4-ft. connection to each conduit supplies water through a gauging tank to the previously existing aqueduct conveying water from reservoirs at Staines to Kempton and Hampton. This aqueduct runs along close to the new reservoir on its northern side. Close to the gauging tank the conduits are reduced to 6 ft. in diameter, and one is capped off at present, but will be continued in the future when required. The other runs on to Kempton, to supply reservoirs and filtration plant there, the water, after treatment, being delivered to various districts in the north and west of London. From Kempton, the conduit from Littleton is continued, at a diameter of 4 ft., to the Board's filter beds at Hampton, whence it is distributed to the southern and western districts of London.

In describing the works it will be both logical and convenient to follow the course of the water from the Thames to the reservoir and thence to the outlet conduits, dealing first with the actual connection with the river. This, as previously mentioned, is made just below Penton Hook lock, and a photograph of the intake, taken from the river looking upstream, is reproduced in Fig. 2, on page 594. The water enters the channel below a bridge formed of mass-concrete arches, faced with granite, and carrying the towing path, as shown in Fig. 2, and also on the left of Fig. 3, which is a plan of the bridges, Venturi meters, &c., at the river end of the intake channel. The towing-path bridge has three spans of 18 ft., as shown in the illustrations, the rise being 3 ft. in each case, while the total width between the centre lines of the parapets is 28 ft. 6 in. Of the latter, it should be mentioned, that on the river side has been fitted with an iron rail specially designed so as to permit towing ropes to pass over it without obstruction. Floating timber booms, clearly shown in Fig. 2, are provided to prevent boats, and other large floating bodies, from passing under the arches, the booms having connections at each end which fit into grooved castings bolted to the piers so that the booms can rise and fall as the water level in the river varies. Steel sheet piling was driven into the bed of the river to enable the work of constructing the bridge to be carried out in the dry. This piling, cut off to a suitable level, has been left in position to protect the foundations of the abutments, piers and apron from erosion. The bank on each side

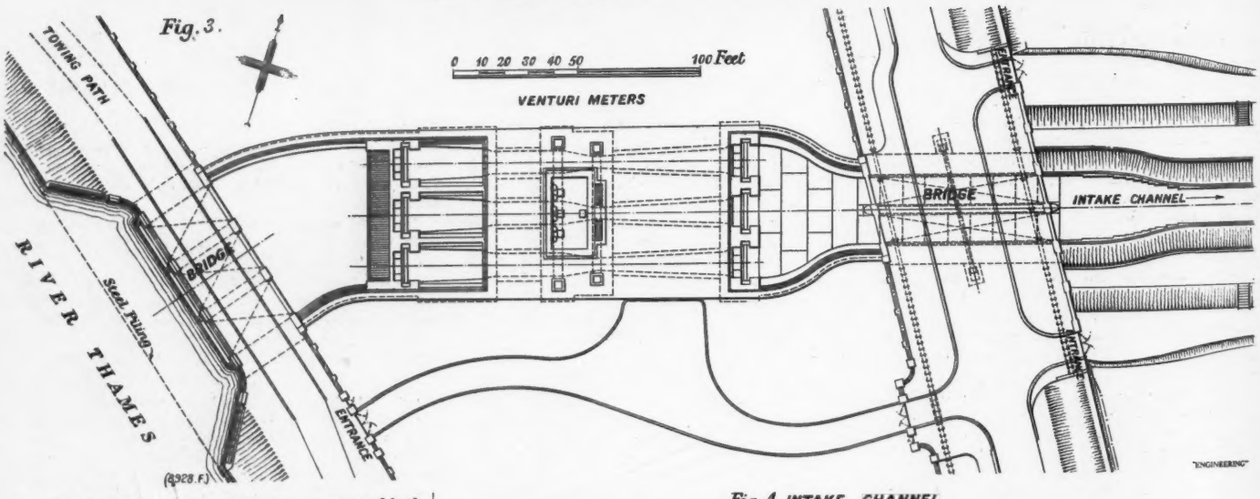
Fig. 1.



THE LITTLETON RESERVOIR OF THE METROPOLITAN WATER BOARD.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER.

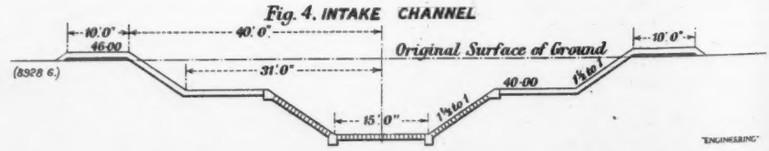
FIG. 2. THE INTAKE FROM THE RIVER THAMES.



of the intake is protected by concrete-block pitching.

Immediately after passing under the towing-path bridge, the water flows through a screen and through roller sluices into three separate channels, each of which leads to a Venturi meter, as will be clear on reference to Fig. 3. The screens are formed by 2½ in. by ½-in. bars spaced 2 in. apart and are arranged in two tiers with a horizontal grating between them, the horizontal portion forming a convenient means of access for cleaning the lower portion of the screen. The water level, it should be mentioned, does not rise above the lower portion of the screen under normal conditions. The sluices, which measure 6 ft. by 12 ft., are operated by hand gear from the top, as shown in Fig. 16 on Plate XXXIX, which illustrates the central sluice in the closed position. These sluices, and others which will be referred to later, were constructed by Messrs. Ransomes and Rapier, Limited, Ipswich. The three channels controlled by the sluices are constructed of mass concrete with sides formed to a batter of 1 in 6, and have concrete block facings for the lower portion and granite facings above. The bottom of each channel is curved downwards to lead the water through circular conduits, 9 ft. in diameter, to the Venturi meters, the location of which is indicated in the plan, Fig. 3.

Fig. 4. INTAKE CHANNEL



We have already dealt very fully with these meters, which were illustrated in detail on Plate XXXII, published with our issue of October 6, 1922, and described on page 418 of that number of ENGINEERING. We may remind our readers, however, that they are each 9 ft. in diameter at the mouth and 4 ft. 10 in. in diameter at the throat, the length of the tapering portion between the mouth and throat being 15 ft. 10⅞ in., while that between the throat and outlet is 54 ft. 1⅛ in. Gun-metal liners are fitted at the mouth and throat, and connections from these liners are taken to float chambers in the meter house above; passages formed in the concrete enable the pressure tubes making the connections with the liners to be examined and cleaned when necessary. The metal parts of the meters and the recording apparatus were made by Messrs. G. Kent, Limited, Luton, and each of the meters is capable of registering flows ranging from 10,000,000 to 100,000,000 gallons in 24 hours.

Roller sluices, similar to those above referred to, but measuring 9 ft. by 12 ft., control the outlets

THE LITTLETON RESERVOIR OF THE METROPOLITAN WATER BOARD.

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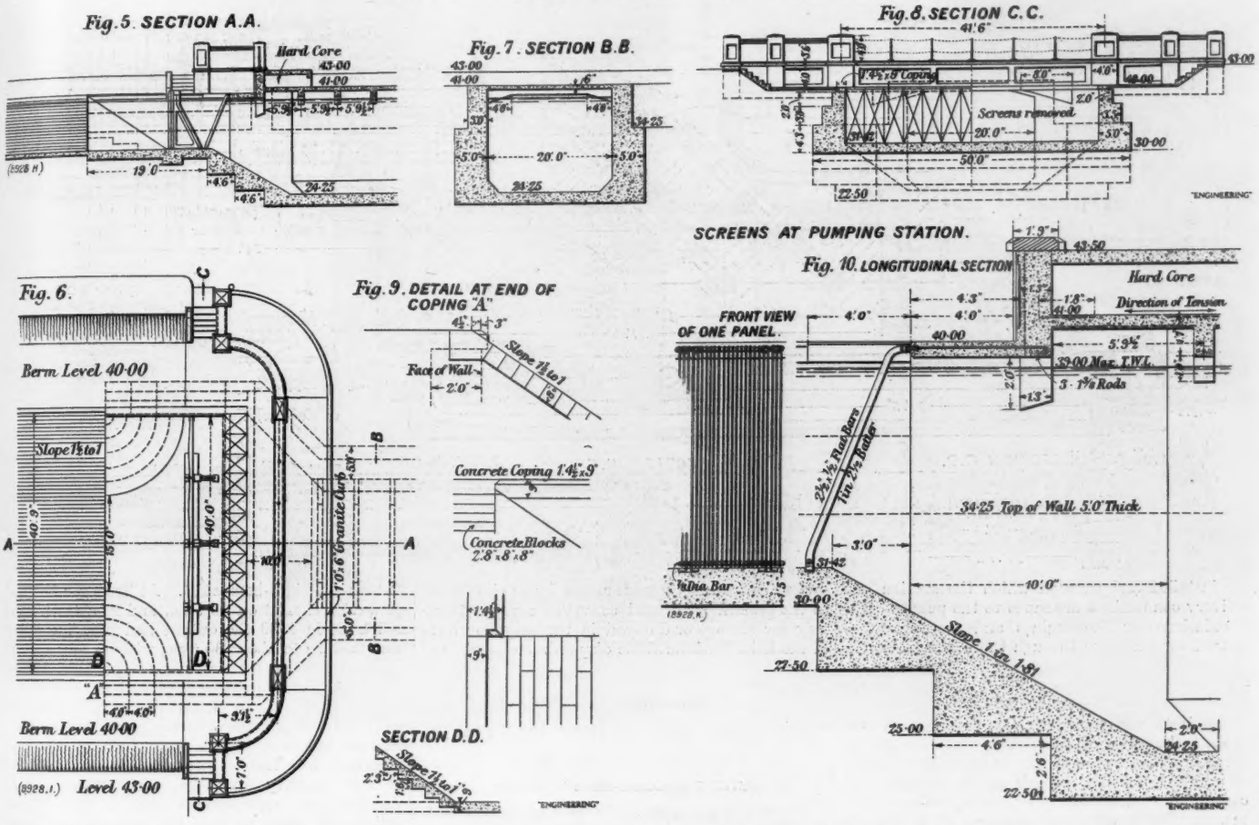

from the Venturi meters, the discharges from which are combined, passing immediately afterwards under a bridge carrying the road running between Laleham and Staines. The bridge is generally similar in design to that carrying the towpath. There are two arches of 12 ft. span and 4 ft. 6 in. rise, constructed of mass concrete and faced with granite, the width of the bridge between the centre lines of the parapets being 67 ft. 3 in. From this bridge onwards the channel is of trapezoidal form, the dimensions being given in the cross-section, Fig. 4, opposite, while a photograph illustrating a curved portion in course of construction is reproduced in Fig. 17, on Plate XXXIX. The latter shows the concrete-block pitching with which the sides are lined and the concrete coping blocks with which the pitching is terminated. The pitching blocks, which measure 8 in. by 8 in. by 2 ft. 8 in., were moulded in Winget machines, as also were those for lining the embankments of the reservoir itself. The pitching for the reservoir embankments, however, has not yet all been placed, and this work will not be carried out until the reservoir has been partly filled, and the material composing the embankments has been consolidated by the action of the water. It will be noticed from Figs. 4 and 17, that earth embankments have been formed on each side of the intake channel, their object being to prevent the access of flood water to the surrounding land.

A single arch accommodation bridge, 12 ft. in width of reinforced-concrete, has been constructed over the channel some 1,500 ft. from the river intake, its position being indicated in Fig. 1, and about midway along its length the channel is spanned by a bridge carrying the Laleham–Ashford road. This bridge, a view of which is given in Fig. 18 on Plate XXXIX, is of mass concrete construction with granite facings, the two arches being of 12 ft. span and 4 ft. 3 in. rise; its width between the centre lines of the parapets is 65 ft. On the northern side of the bridge is an entrance to a road which has been specially constructed to give access to the pumping station. The road follows the course of the channel, and consists of a tar-macadam cartway 20 ft. in width, with granite kerbs and channels.

At the pumping station, which is located at the foot of the reservoir embankment about three-quarters of a mile from the river intake, the water passes through a screen and under a bridge, both of which are shown under construction in Fig. 19, into a suction basin from which four tunnels lead, one to each of the pumps installed in the pumping station.

Drawings of the bridge and screen and of the entrance to the suction basin are reproduced in Figs. 5, 6, 8 and 10, above, while the details in Fig. 9 illustrate the coping at the point where the trapezoidal channel is connected to the rectangular channel in which the screen is located. In front of the screens, it may be mentioned, cast-iron stanchions have been provided, so that stop planks can be placed in position to close the entrance to the suction basin in case of emergency. The suction basin, sections of which are given in Figs. 7, 11, 12, 13 and 14, page 596, is a rectangular concrete chamber measuring 94 ft. 2 in. long, 20 ft. wide, and 16 ft. 3 in. high, internally, covered with a roof formed of reinforced-concrete beams and slabs.

Of the four suction tunnels, two are connected to one side of the basin, one at a corner and one at the end, as shown on the plan, Fig. 11. The tunnels, which are formed in the concrete, are of circular section and are 7 ft. in diameter at the inlet ends, the diameter being first reduced to 6 ft. and afterwards tapering down to 5 ft. near the outlet ends, from which riveted-steel bends, embedded in the concrete, lead up to the pump casings in the engine-room basement. The connections to the pump casings are 4 ft. 6 in. in diameter, and the reduction to this diameter from 5 ft. is effected by tapering the bends themselves. Fig. 12 gives a longitudinal section through one of the suction tunnels, and shows most clearly the manner in which the diameter is reduced between the inlet and outlet ends. The arrangement of the delivery pipes is also shown in Figs. 11 and 15, but we shall deal with these in a subsequent article.

The general arrangement of the pumping station buildings, which were erected by Messrs. John Laing and Sons, Ltd., of London and Carlisle, is illustrated in Figs. 20, 21 and 22, on Plate XL, which give, respectively, a transverse section, a longitudinal section through the engine room and a longitudinal section through the bunkers constructed over the firing floor of the boiler room. Fig. 23, on the same plate, is a plan of the complete station showing the general arrangement of the boilers, engines and pumps, while Figs. 24 and 25, on Plate XL are reproduced from photographs showing the exterior of the buildings and the plant installed in the engine room. The buildings are constructed of red brick with Portland stone dressings, giving a particularly pleasing external appearance as can be seen, to some extent, in Fig. 24. More than half of the main building is occupied by the engine-room, which measures 127 ft. long internally, by 59 ft. in width. It contains four pumping sets each comprising a 770 B.H.P. single-cylinder, horizontal steam engine of the Uniflow type, directly coupled to a 48 in. low-lift centrifugal pump, both engines and pumps having been constructed by Messrs. Worthington-Simpson, Limited, Queen's House, Kingsway, W.C. 2. The axes of the engines and pump are placed at an angle of 45 deg. with the walls, as shown most clearly in the plan, Fig. 23, this arrangement serving to economise space in the engine room and also facilitating the lay-out of the suction and delivery mains. A hand-operated overhead-travelling crane by the Vaughan Crane Co., Limited, having a lifting capacity of 12 tons, is provided in the engine room for handling parts of the plant during overhauls and repairs. Below the engine-room floor is a basement, in which the air pumps and condensers

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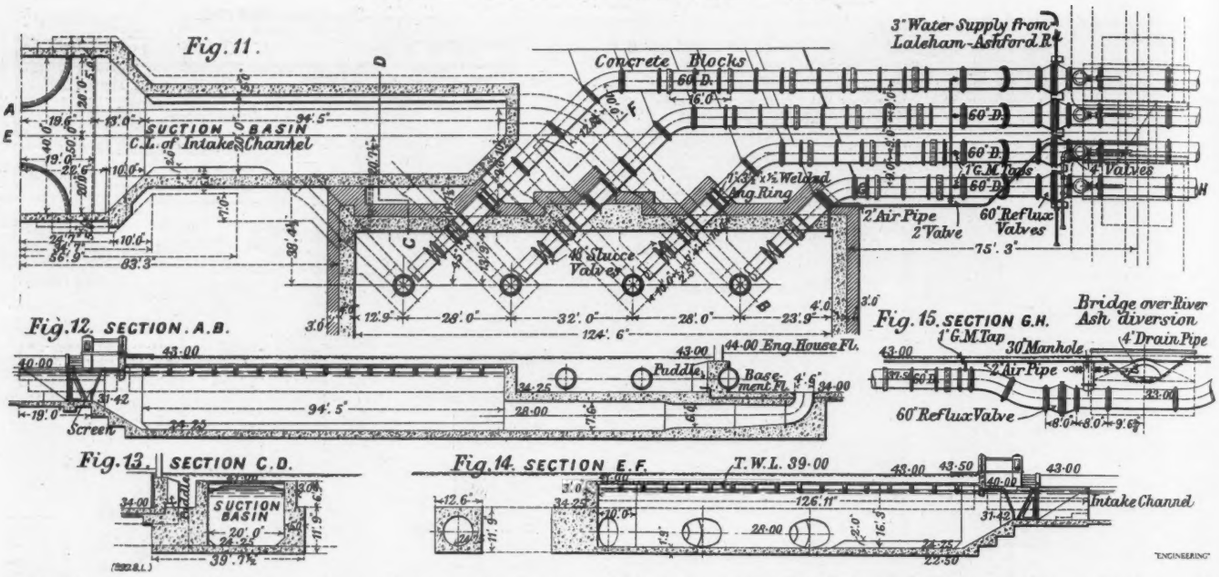
MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER.



are installed and through which the suction and delivery connections are made to the pumps. The foundations for the engines and pumps are, of course, carried down through the basement to the subsoil. Access to the basement is obtained by staircases leading down through openings in the floor of the engine-room, as indicated in Fig. 23.

Adjoining the engine-room on the southern side is the boiler-room, communication between the two being provided by double glazed doors, on the right of which is located a small glazed compartment containing various indicating and recording instruments. The boiler-room measures 88 ft. long by 62 ft. wide, and has been designed to accommodate five Stirling boilers, each having an evaporative capacity of 8,300 lb. per hour. All the boilers, which were manufactured by the Stirling Boiler Company, Limited, are set singly in one row, as shown in Fig. 22, but at present only four are actually installed. They are arranged in two pairs at the ends of the boiler-room, space having been left between them for the installation of the fifth boiler, if this should prove to be necessary in the future. The boilers work under natural draught supplied by a brick chimney, 150 ft. in height, and superheaters and economisers are provided for each, but as we propose to deal more fully with the whole of the pumping-station equipment in a subsequent issue it is unnecessary to refer to them in greater detail now. Attention may, however, be drawn to the arrangement of the coal bunkers, which are best shown in Figs. 20 and 22 on Plate XL. These are constructed of reinforced concrete, the dimensions being indicated in the illustrations referred to, and it will be seen that one bunker is provided for each boiler. The bottoms of the bunkers are in the form of pyramidal hoppers, the outlets of which are connected by steel chutes to the hoppers of the chain-grate stokers with which the boilers are equipped.

Coal is supplied to the station by lorries, the access road, above referred to, being continued round the station at the eastern end, so that the coal can be dumped directly into a hopper located in the corner between the boiler house and engine-room, as shown on the left-hand side of Fig. 23. From this hopper, the coal is raised by a gravity bucket conveyor and carried along over the bunkers by the same conveyor, from which it can be dumped into any of the hoppers as required.

For handling the ashes, a tunnel has been constructed under the firing floor, as indicated in Fig. 20, and the ashes drop from the grates into wagons running on rails in this tunnel. When filled, the wagons are pushed along by hand to the eastern end where they are raised by an electric lift to the ground level, and conveyed along a tramway for storage or dumped in the neighbourhood of the hoist for immediate disposal.

(To be continued.)

THE IRON AND STEEL INSTITUTE.

(Continued from page 581.)

BRITISH ROLLING-MILL PRACTICE.

THE first paper taken at the meeting on Thursday, the 7th inst., dealt with "Progress in British Rolling-Mill Practice." It was by Mr. T. W. Hand, who read it in abstract. The author first called attention to a paper read at an earlier meeting of the Institute by Mr. W. Garrett,* comparing the British and American rolling-mill practice under the conditions which prevailed about 25 years ago. As we were faced in this country at the present time with competition of a very serious nature, it had occurred to Mr. Hand to make a comparison of the conditions now obtaining in both countries in the same branch of industry. The paper gave detailed illustrated descriptions of notable British and American rolling-mill lay-outs, stated the duty of the plant, mechanical data, output, class of work, &c.; it also contained suggestions for improving the working and developing the output of British mills. We propose to reproduce this paper in a future issue.

The discussion was opened by Mr. F. Anslow, who stated that the author had omitted from his list of mills an entirely new plant recently put down by the Scottish Iron and Steel Company, which included modern rolling mills electrically driven throughout, the current being generated by mixed pressure turbines. Many of the comparatively heavy mills put down in this country were difficult to keep in regular working when trade fell off. On the other hand, smaller mills could be run more cheaply, but they "could not rise to the occasion" when trade became good again. The author's illustration of the Parkgate Company's rolling-mill installation of a three-high plate mill having rolls 28 in. and 18 in. by 6 ft. 6 in., was a plant which one might reasonably expect to meet the conditions he (Mr. Anslow) alluded to. A mill of this nature was capable of a large output resulting in a decrease in cost of production.

Captain L. D. Whitehead was astonished at the output given for this mill, the average output of 4-in. flats for any prolonged period being about 20 tons per eight-hour shift. At Tredegar he (the speaker) reckoned on 48 tons, and in a three-high mill built in 1900 the output had been increased from 25 tons to about 80 tons, without any special machinery. The author's mill started from billets or blooms measuring from 3 in. by 3 in. to 7 in. by 6 in. and 34 in. to 72 in. in length; that had been his own practice in former times, but he now used no billets or blooms beyond the 4-in. The Tredegar mill had worked to 96 per cent. of its full capacity for years past. It was most essential when contemplating putting down a new rolling-mill plant to site the mill in the right place—namely, close both to a cheap source of supply and to an export centre. He had put down at Newport at a time when costs were at their highest, a 12-in. hoop mill, but this mill was giving satisfaction and was working economically, seeing that it was in very close proximity to the docks. Easy and cheap transport and stocking facilities were points on which emphasis must be laid. Given possible output and right position combined, there was room in this country for continuous billet and bar mills.

Mr. L. Rothera endorsed the author's statement to the effect that if many of the British cogging and slabbing mills were fully supplied with ingots they would reach the high American tonnages. With reference to another statement regarding the fact that in America all movements of the mill were handled by two men, there being in use a combination of hand and foot-controlled master switches, he asked the author whether he had seen one of these mills in operation. The method of control in question might not be completely satisfactory for fine speed adjustments. In the matter of the further statement to the effect that in mill practice generally many improvements had been effected in mechanical details, which had greatly stimulated output and had also enormously reduced manual effort, he considered that such a practice was the aim of most modern plants. The interesting feature of the Lackawanna plant, *i.e.*, the use of a reversing-type mill motor for driving the three-high mill, was one which could also be found in British rolling-mill plants. In future, no doubt, the first eight, nine, or ten passes would be taken reversing; the time interval of the first passes would be four seconds, and two seconds for the last passes, with, as a consequence, an increased output. A further consequence would be an improvement in the wear of the roll necks, on which no pitting would occur, and this was an important point in the case of a plate mill; the wear on the pinions would also be decreased. The author had

* See ENGINEERING, vol. lxxi, pages 616, 630, 641 and 652.

(To face page 596.)

INTAKE WORKS OF THE LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(*For Description, see Page* 593.)

FIG. 16. ONE OF THE ROLLER SLUICES AT THE INTAKE.

FIG. 17. CURVED PORTION OF INTAKE CHANNEL SHOWING CONCRETE-BLOCK PITCHING.

FIG. 18. BRIDGE OVER INTAKE CHANNEL CARRYING LALEHAM–ASHFORD ROAD.

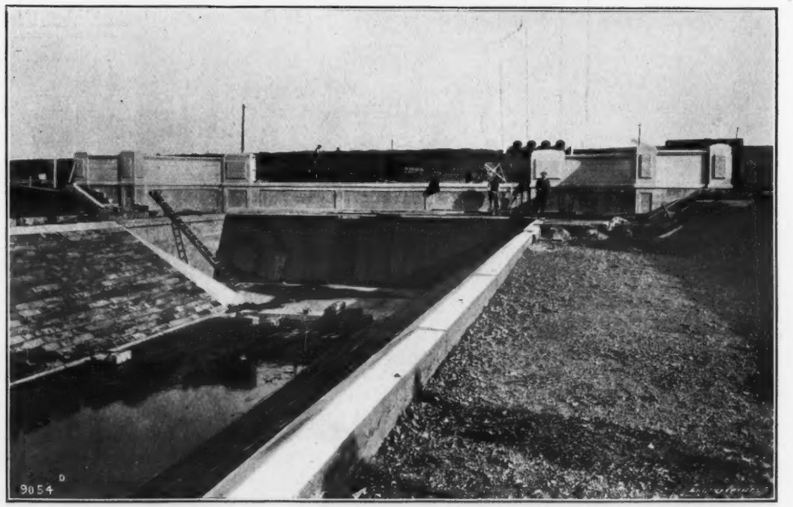


FIG. 19. SCREEN AT ENTRANCE TO SUCTION BASIN.

PUMPING STATION FOR THE LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(*For Description, see Page* 593.)

Fig. 20. SECTION C-C.

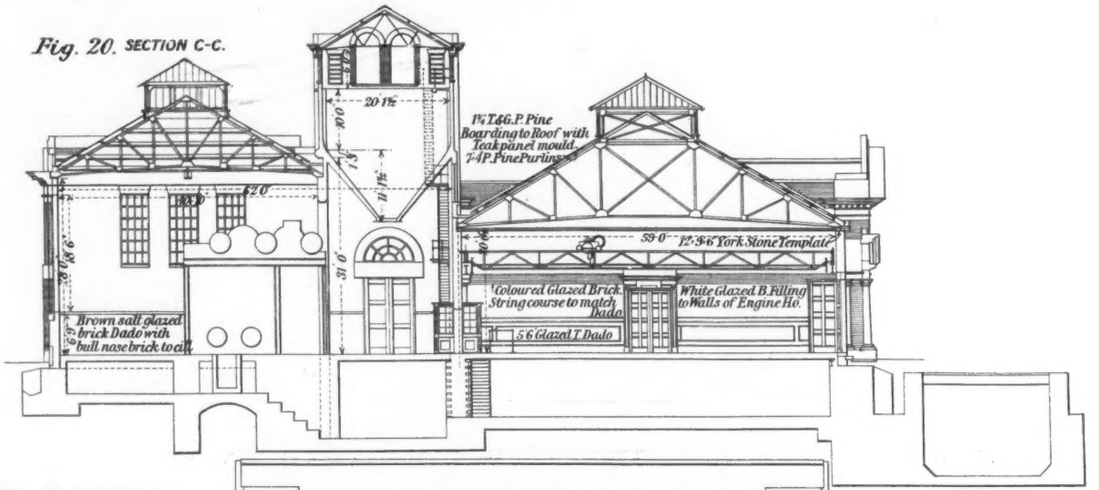


Fig. 21. SECTION A-A.

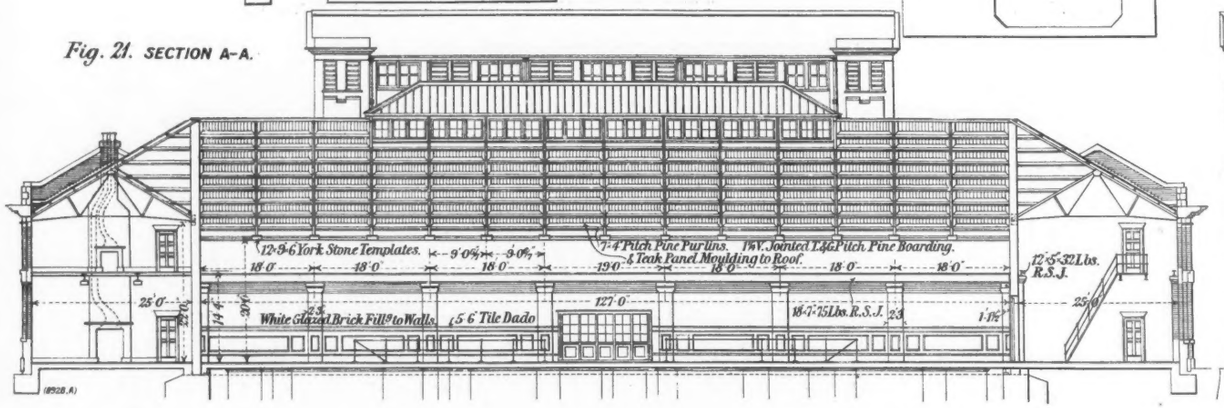


Fig. 22. SECTION B-B.

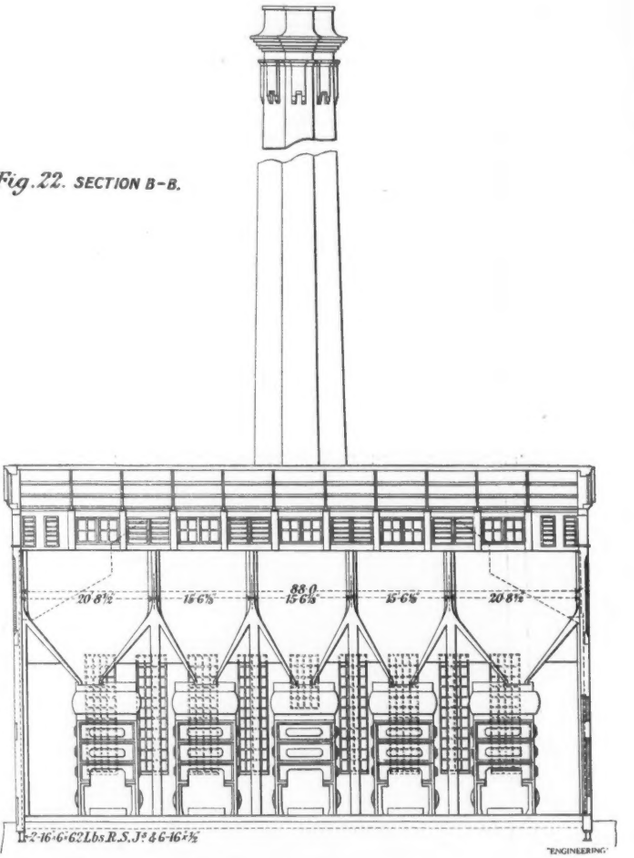
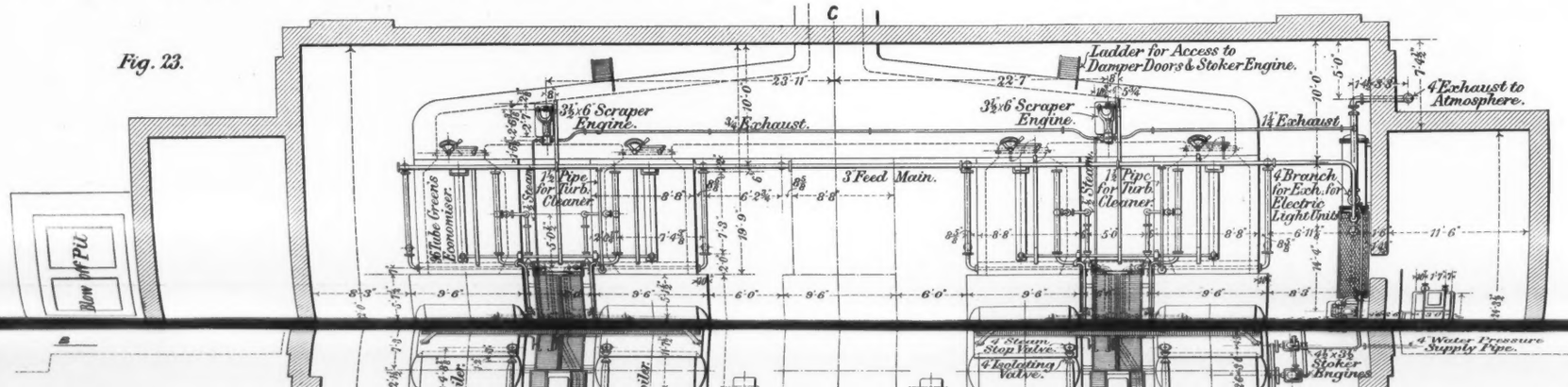
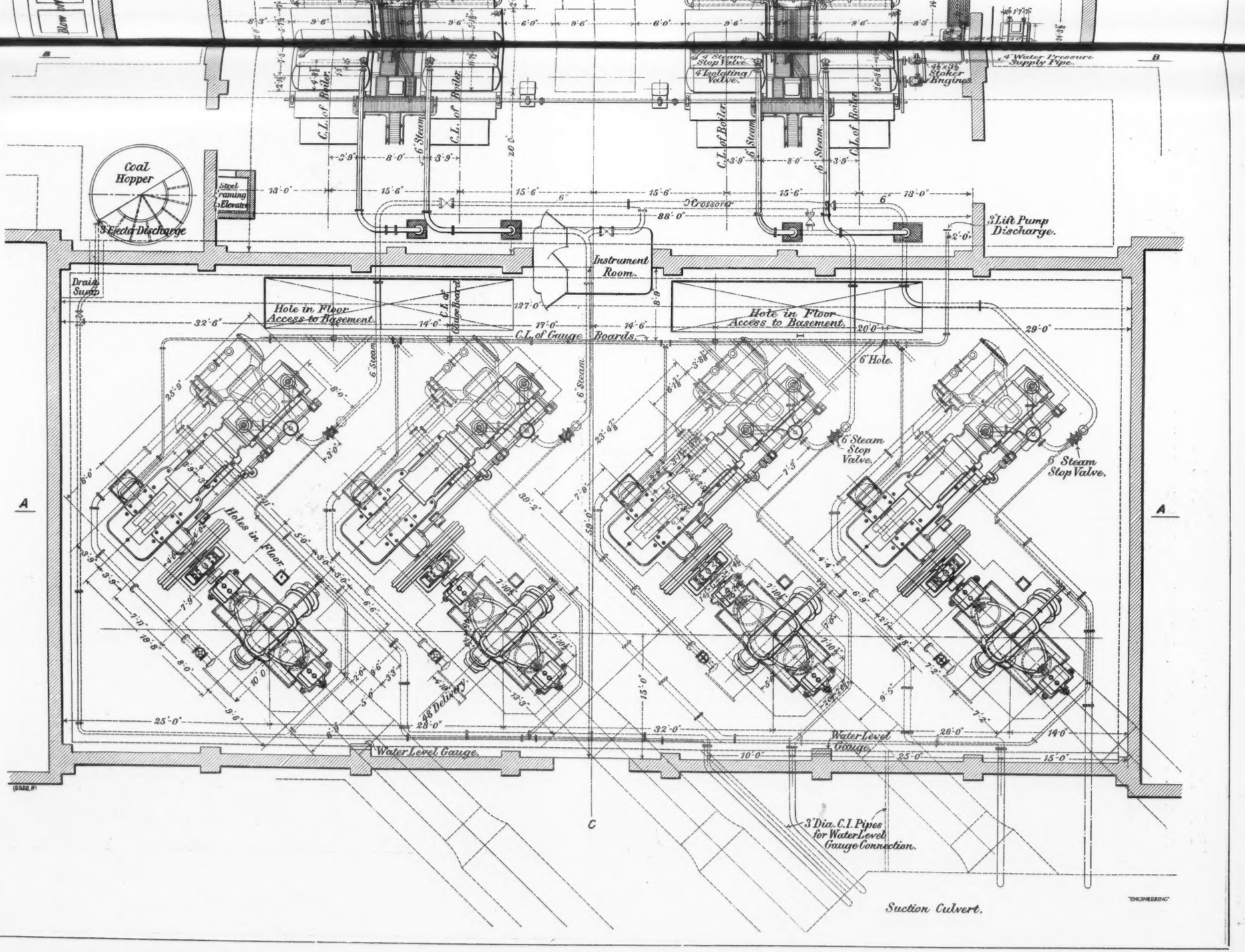


Fig. 23.




Coal Hopper
3" Ejector Discharge
Steel Framing Elevator
Instrument Room.
3" Lift Pump Discharge.
Drain Sump
Hole in Floor Access to Basement.
C.I. of Gauge Boards.
Hole in Floor Access to Basement.
6" Hole.
6" Steam Stop Valve.
6" Steam Stop Valve.
Holes in Floor
48" Delivery
Water Level Gauge.
Water Level Gauge.
3" Dia. C.I. Pipes for Water Level Gauge Connection.
Suction Culvert.
C.L. of Boiler
6" Steam
4" Steam Stop Valve.
4" Isolating Valve.
4" Water Pressure Supply Pipe.
45"×24" Stoker Engines
3 Crossovers
"ENGINEERING"

PUMPING STATION FOR THE LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(*For Description, see Page* 593.)

FIG. 24. PUMPING STATION LOOKING TOWARDS INTAKE CHANNEL.

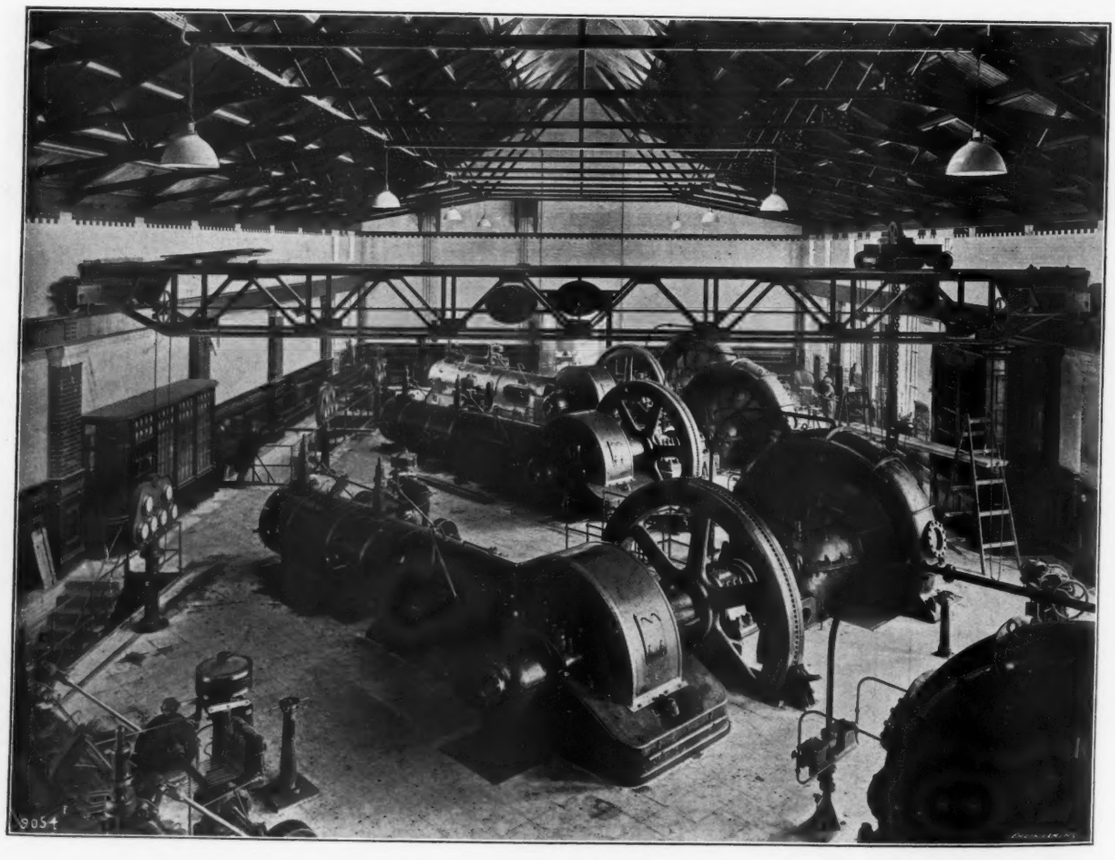


FIG. 25. INTERIOR OF ENGINE ROOM.

(*To face page* 597.)

mentioned an instance in which a mill had produced 3,000 tons of sheared plates per week. He could refer to an actual output of 4,000 tons in that week. Regarding the 16 kw. per ton given in the paper for the power consumption of the Homestead three-high plate mill, it would be interesting to know whether this was on the finished or actual product of the mill. The author had also given a few data on an American plant consisting of a 44-in. reversing blooming mill, a 35-in. reversing roughing stand, a two-stand, 28-in., three-high intermediate mill equipped with travelling tilting-tables, and a 28-in., two-high, continuously running finishing stand, all units being independently driven. He would like to ask whether the author advocated the use of such a large plant in this country under the conditions now ruling.

Mr. H. B. Toy stated that the most modern plants he had seen had been designed abroad or supplied to this country from abroad, a fact that was much to be deplored. Dealing with the shearing of plates, he wished to ask whether it was necessary to turn them round for shearing both sides. The universal mill was no doubt a wonderful machine, but there was some difficulty in keeping the plate perfectly straight. The importance of having ample power and speed to take the material through at the shortest time intervals with the least possible number of passes could not be overrated.

Sir William Ellis expressed the opinion that there was still a great amount of modernising to be done in this country with rolling mill work, and many managers would be only too pleased to act in that direction if the state of the industry were better and enabled them to do so. The financial situation, however, was so unfavourable that new schemes could not be put into execution. But existing plants could no doubt be improved with a view to lower the cost of production. Plants now operated by low-pressure steam probably brought from a distance could not possibly compete with others that were electrically driven. Some years ago many steel works would have found difficulty in obtaining an adequate current supply. This had been remedied to a large extent. The economy of electric driving had been ascertained in machine shops and shipyards; it would be found to obtain in rolling mills also.

In the course of his reply, Mr. Hand stated that he was not responsible for the figures of output he had quoted; they had been given him. It represented an average output; matters might be improved, but it represented a good average. The foot and hand control had been introduced in the United States since he had left that country; considering the foot control on motor-cars and the accurate way in which it worked, he would not imagine that there occur any difficulty under that head. The 16 kw. quoted as power consumption referred to the slabs fed into the mill and not to the finished plates. The 44-in. blooming mill was the American rating, the pinion rating; the rolls would be about 40 in. The mills in this country had not all been built abroad. The Morgan type of mill was designed abroad, but built in this country; one or two universal mills had also been designed abroad. Apart from these instances the plants were from this country. The universal mill served quite a useful purpose, and he thought its arrival here had been somewhat belated. It rolled wide tube strips, and the usable product was 90 per cent. of the steel fed in, instead of 75 per cent. when working sheared plates. The latest types of plant were being put down in France, Belgium, Spain; the United States had put them down for years past. How was it, he asked, that we in this country were satisfied to continue working plants put down in some instances as long as forty years ago.

Flakes or Hair-Cracks in Chromium Steel.

The second paper was entitled "Flakes or Hair-Cracks in Chromium Steel, with a discussion on Shattered Zones and Transverse Fissures in Rails." It was by Mr. A. Hultgren, Gothenburg, who read it in abstract. A defect which came to be known as flakes or hair cracks, having been noticed from time to time in the manufacture of ball and roller bearing steels, the author had carried out rolling and forging experiments under varying conditions with a view to its elimination. The author's researches showed that the flakes when present invariably formed during cooling after the final hot-working operation, and that their formation was prevented by retarded cooling. The author believed that flakes could occur in steel of great purity and thought that his investigation provided examples of this. On the other hand, flakes could probably be avoided, even in steel having many inclusions, by properly controlling the cooling conditions after hot-working. We hope to reproduce the paper in abridged form in a future issue.

Dr. W. H. Hatfield stated that the author had dealt with a problem of the greatest interest to all alloy-steel makers. The term "snow-flakes" was an American term and applied to quite a serious problem in America. It was apparent that the same problem existed in Sweden. It had also been a problem here, but in the works he was connected with the trouble was now completely under control and the difficulty was overcome. He did not think the author's conclusions would be helpful in preventing the occurrence of "snow-flakes." Whatever care the author might take in the heat-treatment of a steel potentially able to develop cracks, those cracks would develop during the treatment. What was needed to eliminate the trouble was to control the reactions in the furnace, the teeming temperature and the teeming speed, for the defect was entirely an ingot defect. The trouble was in the ingot. The author had stated that such flakes when present invariably formed during cooling after the final hot-working operation, and that their formation was prevented by retarded cooling. How could he say that inside a billet or a bloom the cracks were not extant previous to the treatment? Data on the metallurgical operations before rolling took place would have to be given. During the war the question of "snow-flakes" in the United States was a very serious one indeed. He knew of a piece of steel brought from over there which, when sectioned and examined, showed no defects, whilst when etched these particular defects developed. These so-called defects might not really be defects, but might easily develop into such. He repeated that the trouble when it existed was located in the ingot, and there was no difficulty in exercising the necessary control.

Mr. H. Brearley, referring to the author's illustrations (Figs. 6 and 7) of a fracture of a hardened disc from a 160 mm. forged bar, said he did not think that all the defects shown were due to the ingot, but most of them were. Some might also have been formed during the forging operation. He had been associated for ten years with ball-race manufacturers before he actually saw a "snow-flake," and then he did not see another until the war. If a steel ball-race happened to be forged in an iron works it was very liable to get overheated and to develop "snow-flakes."

Mr. E. H. Saniter thought that the paper dealt with a number of things, but really with cooling cracks. In hard steel clinks occurred, and the author's cures for the occurrence were the best suggested.

Mr. T. H. Turner said the occurrences, as shown in the author's different illustrations, were not necessarily due to the same phenomenon, and in one case the defect was like a clink. All the steels referred to were hardened, and the question which had to be settled was as to how the flakes were to be avoided and yet the hardening of the steels arrived at. The type of defect mentioned was frequently the beginning of fatigue fracture. In perfectly good steel, cracks would also occur in service.

Dr. W. H. Hatfield stated that in armament works the whole of the alloy steel had to be cooled quickly, with, as a result, the production of great internal stresses; if, therefore, the steel was not perfectly sound in the ingot form, it was likely not to be of great use in the engineering industry.

Mr. H. H. Ashdown agreed partly with the author and partly with the remarks made by Dr. Hatfield. The clinks did occur in the cooling-down after forging, and the trouble could be traced largely to non-metallic inclusions; the defects did not occur in the dendritic area. In some samples, the clinks were right in the interior of the inclusions and during the war the trouble was very prevalent. The author had endeavoured to illustrate these clinks, or "snow-flakes" as the defect was styled in America. The author's paper, he believed, would be found of great service. His own opinion was that provided care were exercised in the cooling process, flakes could be avoided. The author had worked on small specimens. In his own experience he had to deal with pieces weighing from 10 to 50 tons, some of which were of great length, and means had to be devised for satisfactorily cooling these rapidly in such a way that the troubles referred to disappeared.

Dr. T. Swinden, referring to the author's views (Figs. 9A and 9B) of sections of 95 mm. by 95 mm. billets, polished and treated with iron-dust on a magnet, was not clear as to whether the defects they showed were similar to those in his three views of fractures of discs. He, Dr. Swinden, had had experience with the defect illustrated in Fig. 9B, but the difference was that the fissures or cracks did not present a coarsely crystalline area but silvery bright areas, except on the outside surfaces, where slight oxidation took place. He had experienced, notably, trouble with a tungsten magnet steel, containing 6 per cent. of tungsten, and in the early days the trouble was pronounced; it was traced to non-metallic inclusions. He cut out the aluminium entirely when teeming, and used titanium in its place, when a considerable improvement resulted, but the trouble was not entirely removed. The type of defect under discussion did arise after rolling or forging, and although developed following these operations, could be traced up to the steelmaking process. Attention had to be paid to the slag condition, the teeming speed and other factors, of which the teeming speed was a very important one, namely, the speed in seconds per foot rise up the ingot mould.

Mr. W. T. Griffiths thought that there was a possibility of the remarks made on both sides being brought together. It might be that a weakness developed during slow cooling; also that by not paying proper attention to the melting and casting conditions, an impurity was introduced which made itself visible later, resulting in the setting up of weakness.

Mr. Hultgren, in the course of his reply, stated that the defect in question was more varied in its occurrences than he had himself thought, and was also, probably, more complicated than the members who had taken part in the discussion themselves thought. He had endeavoured to solve a part of the problem, and had received the assurance of manufacturers that their trouble in this respect was now over. "Snow-flakes" in nickel-chromium steel might in some cases not be identical with what he had described. He did not think his evidence had been questioned in regard to the particular steel he had experimented with. It was difficult for him to reply off-hand to the discussion. The flakes he had described were not areas of weakness, but actual cracks. They could be seen under the microscope. It would have been interesting to have from Dr. Hatfield particulars of the methods he used for arriving at a perfectly sound ingot, and further evidence to prove his contention. The quality of the steel as cast must, evidently, have an influence, but the particular cracks he had mentioned were formed in cooling after hot-working. In no case did he find any after retarded cooling. Since they were formed during that cooling process, if the cooling rate was sufficiently fast the trouble must be the result of cooling stresses. If this were admitted, the main factor in the cases under review must be the cooling stresses. By slow cooling, he repeated, the trouble was avoided. If the discussion were confined to the particular defect under review, there was no reason, he thought, for him to take back any of his statements.

Strain in Mild Steels.

The first papers taken at the afternoon session on Thursday, the 7th inst., were "The Detection of Strain in Mild Steel," by Mr. T. H. Turner and Mr. J. D. Jevons, and with "Strain Detection in Mild Steel by Special Etching," by Mr. J. D. Jevons. They were discussed together. We reproduced both in abridged form on pages 585 and 588 *ante*.

Dr. Rosenhain considered the authors had given an interesting series of photographs; they formed a

successful application of Dr. Fry's etching methods. The authors had made use of a new term when referring to "distortion wedges." By this they no doubt meant that distortion started from a point of maximum stress, where plastic deformation commenced, and spread along lines, then gradually tailing off. The distortion wedge was a triangular mass of metal. This was not quite a novel occurrence. An interesting point was the fact that in order to effect etching the piece had to be subjected to heating, to about 200 deg. C. for a few minutes; this was a striking fact because the heating removed some of the stresses in the steel. He would like to know if the authors had made experiments with the metal after a prolonged rest.

Mr. Stromeyer exhibited a few samples etched on the Fry process, showing lines like pencil marks, and also lines produced by shearing. He considered that a short exposure to a high temperature gave the best results for the Fry process of etching.

Mr. W. H. Patchell said that what was wanted was a ready means of testing steel when delivered to engineering works.

Dr. W. H. Hatfield expressed the opinion that the authors were dealing with an interesting piece of work. If a method such as the one they had described could conveniently be adopted for disclosing the existence of stresses in boiler plates, it would have the effect of exposing the crudity of the processes followed by the boiler makers in working up the plates supplied to them by the steel makers. Very often the trouble with the boilers would be found to be traceable to the serious distortion set up round the rivet holes. An interesting point brought out by the papers was that the maximum etching produced was coincident with the critical amount of cold work which had caused grain growth.

Professor Desch stated that when Dr. Fry's paper appeared he had tried to repeat his results but had failed. There was a difference between the authors' and Dr. Fry's steels and he would like to know what that difference was. The authors' analysis did not show oxygen and hydrogen, and that might account for the difference.

Mr. T. H. Turner, in replying briefly to the discussion, said they had tested specimens after a long period of rest, but did not think it made much difference. Differences resulted, however, from heating and some of Mr. Stromeyer's specimens might have been under the influence of superheated steam.

Formation of Blowholes.

The last paper taken at the afternoon session on Thursday was one by Messrs. A. G. Lobley and C. L. Betts, entitled "The Influence of Gases at High Temperatures upon Iron, with Special Reference to the Formation of Blowholes." We reproduced this, abridged, on page 591, *ante*. It was read in abstract by Mr. Betts.

In opening the discussion Professor Thomas Turner stated that the two chief factors involved in this matter were, firstly, the rate of contraction of the metal and its ability to freely "feed" itself as contraction took place upon cooling and, secondly, the evolution of gases upon solidification. The latter depended upon the solubility of each gas and the temperature coefficient of that solubility. A number of experiments had been conducted by Messrs. Bamford and Ballard in order to ascertain the effect of various gases upon the casting of brass. It had been found that the question resolved itself into paying due attention to methods of casting. If the pouring were steady and the cooling slow, sound castings could be obtained irrespective of the prevailing atmosphere. To some extent, the same would apply to iron as was suggested by the present authors. The best indications were, after all, obtainable from ice and water. If water were cooled slowly, "black" ice was produced. If, on the other hand, water were cooled quickly, "opaque" ice full of air bubbles in the form of globules was obtained. It was necessary, therefore, to give the metal sufficient time before pouring in order to facilitate the evolution of the excess gas present. An important point recorded by the authors related to the effect of carbon dioxide. They had shown that it was less soluble and more injurious to the steel than hydrogen or carbon monoxide.

Dr. A. McCance stated that an investigation on such a difficult subject required courage on the part of the investigators. The authors' findings suggested that carbon dioxide was less soluble than carbon monoxide. While this was in his opinion true, there were so many interfering factors that the conclusions they had arrived at could not be said to be definitely proved. The gases issuing from the apparatus should have been analysed, as alterations in their composition might have taken place during the course of the experiments. Moreover, it was difficult to distinguish between shrinkage contractions and blow-holes. He regarded the work of the authors as preliminary, and he hoped that in future researches efforts would be directed to the elimination of disturbing factors. The problem of gases dissolved in steel was of great importance to steel-workers.

Dr. T. Swinden agreed with the last speaker in doubting that some of the conclusions arrived at by the authors were fully warranted. He did not think that the data presented were sufficient to prove that blow-holes were due to carbon dioxide. The monumental work of Brinell upon the subject was well worthy of close study. The conclusions of the experimenters relating to the influence of nitrogen and hydrogen in the formation of blow-holes were, he thought, rather contradictory. They stated, on the one hand, that mere solubility of those gases likely to be present in molten iron did not in itself cause blow-holes, ingots extremely free from blow-holes having been produced in the nitrogen melts. On the other hand, when alluding to the considerable formation of blow-holes resulting in the experiments with pure hydrogen, they tendered as a possible explanation that the rate of cooling was too great to allow the very large volume of gas absorbed at the high temperature to escape during the liquid phase of cooling. Blow-holes as he understood them were formed during the period of solidification of the ingot, and were due to gases being evolved. Hydrogen could not, therefore, be ignored. Baraduc-Muller had, in the course of experiments recorded in the "Carnegie Scholarship Memoirs for 1914," analysed the gases evolved by steel during the cooling from the liquid to the solid, and he had shown that the solubility of hydrogen decreased rapidly with the fall of temperature. The gases consisted, first of all, mainly of carbon monoxide. The proportion of hydrogen given off gradually increased, however, and just prior to solidification he had found that the gases evolved contained 40·8 per cent. of carbon monoxide and 28·4 per cent. of hydrogen. Whilst the surface of the steel was actually setting the proportion of carbon monoxide evolved had decreased to 24·8 per cent. and that of hydrogen had increased to 60 per cent. At a still later stage the figures were: carbon monoxide 15 per cent. and hydrogen 68 per cent. Sieverts had also obtained similar results. The evolution of hydrogen at the time of solidification could, therefore, not be ignored, and carbon dioxide was not the only gas which should be taken into account when investigating the cause of the formation of blow-holes.

In his reply, Mr. Lobley stated that he and Mr. Betts had endeavoured to prevent piping in their specimens. The crucible was cooled down as uniformly as possible; there was little or no reason why the top should cool before the bottom, and no cavities were drawn in. The work they had dealt with was only in its preliminary stages, and they were continuing it. With regard to Dr. Swinden's reference to the influence of hydrogen and nitrogen, he contended that the solubility of the former was so much the greater that it might be the cause of the formation of blow-holes on account of its inability to get away quickly enough during the cooling. Hence the rate of cooling had an important bearing upon the subject, and when continuing their researches, they hoped to pay special attention to this question.

At this point the meeting adjourned. Members reassembled later in the evening at the Hotel Cecil for the Annual Dinner. Among the speakers to the toasts were Sir P. Cunliffe-Lister, K.B.E., Mr. John Hodge, and Mr. Evan Williams. We propose to deal with Friday's proceedings in our next issue.

(To be continued.)

THE GAUGING OF RIVERS AND TIDAL CURRENTS.

Some three years ago the Research Department appointed a Committee on Gauging Rivers and Tidal Currents, which has now submitted its report, accompanied by a report from its technical officer, Dr. M. A. Hogan, on the experimental work that has been carried out for the Committee, and generally on the more important other information that is available on apparatus and methods relating to its subject-matter. The Department has now published Dr. Hogan's report, together with an extract from that of the Committee.* It is a document of 67 pages with numerous diagrams, which will be found valuable not only for the ample summary it gives of results that have been obtained elsewhere, and for its discussion of the conclusions to be drawn from them, but also for the opinions it expresses in regard to the instruments and methods that should be used in a hydrometric survey of this country. The Committee consisted of its chairman, Colonel H. G. Lyons, the late Sir Maurice Fitzmaurice, Mr. D. J. Mathews, Dr. H. R. Mill, and Professor W. C. Unwin. The laboratory experiments were carried out in the Froude Tank of the National Physical Laboratory, and at the Imperial College, South Kensington. The field experiments were carried out on the Severn, near Bewdley, with the help of Professor G. M. Dixon and students from the Imperial College, and on the Liffey, at Burgage Bridge, with the help of Professor Pierce, F. Purcell and students from University College, Dublin. The present report should be read in context with a report on current meters that Dr. Hogan prepared previously for the Committee after inspections of hydrometric work in France and Switzerland.†

The conclusion at which the report arrives is that available means are adequate to gauging both small and large rivers under practically all conditions of flow and for enabling a hydrometric survey of Great Britain to be carried out. The many variations, however, of the flow of water at different times and in different parts of streams and of their beds make it necessary to choose for the gauging of each stream the instruments and methods that are most appropriate, and the largest part of the report, including the whole of the laboratory tests, is devoted to defining the limits of accuracy and circumstances affecting the application of various current meters and methods of using them. Experience has failed to recommend for general use any of the chemical methods that seemed to offer a possible short cut, and further acquaintance with the electrical method of Professor Cleverdon—some of the more modern experiments on which were described in our issue of January 9, 1923—has shown that the electrolytic phenomenon on which it depends is too unstable to be made the basis of a reliable measuring instrument. Where, therefore, circumstances are such as to allow measurements to be made without the use of weirs, some form of mechanical current meter has been employed, and Figs 1 to 3 show three typical forms of the meters that have proved most satisfactory.

Fig. 1 shows the small form of the Price meter, made by Messrs. W. and L. E. Gurley, of Troy, N.Y., which appears to be the most generally useful type on the market for streams in which the velocity of flow is not less than half a foot per second and there is no undue turbulence. It consists essentially of a C-shaped frame carrying the rotating element, which is a wheel made up of six conical buckets and fixed on a vertical axle. This axle is carried and revolves on a hard-steel pivot at the bottom of the frame, and its upper end passes through a bronze bearing, above which it carries a cam within a closed contact-box. By means of the cam connection is made to a telephone receiver, on which the revolutions of the wheel are indicated. In one pattern of contact-box each revolution is signalled on the telephone, and in another, which may be supplied for alternative use on the same

* River Gauging: "A Report on Methods and Appliances Suitable for Use in Great Britain." By M. A. Hogan, Ph.D.A.M.Inst.C.E. H.M. Stationery Office. 2*s*. 6*d*. net.

† "Current Meters for Use in River Gauging." By M. A. Hogan, Ph.D., D.I.C. 1922. H.M. Stationery Office. 1*s*. 6*d*. net.

instrument, every fifth revolution. The receiver is of about 10 ohms resistance, with a single dry cell in circuit. In use the meter may be carried on a rod, but is more usually suspended from a cable, as shown in the figure. The meter is balanced by a tail with four vanes, which serves also to keep it parallel to the direction of the current. It is carried at its centre by a steel rod with a streamline lead sinker at its lower end, which is connected at the top to the cable.

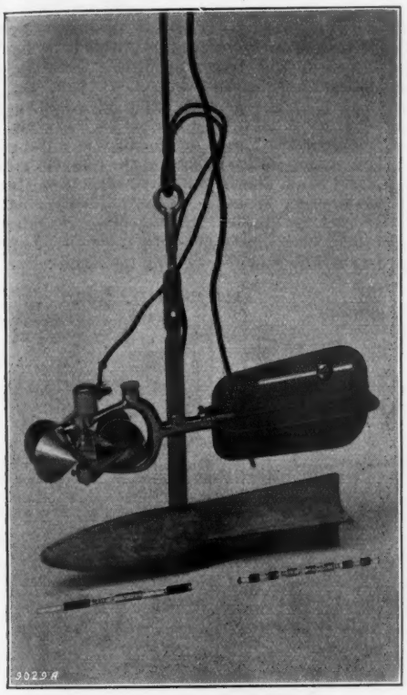


FIG. 1. THE PRICE FLOW METER.

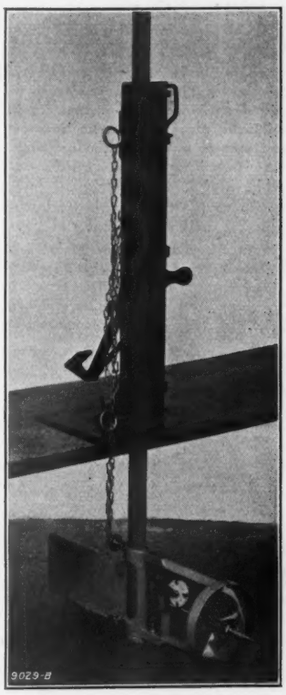


FIG. 3. THE STOPPANI FLOW METER.

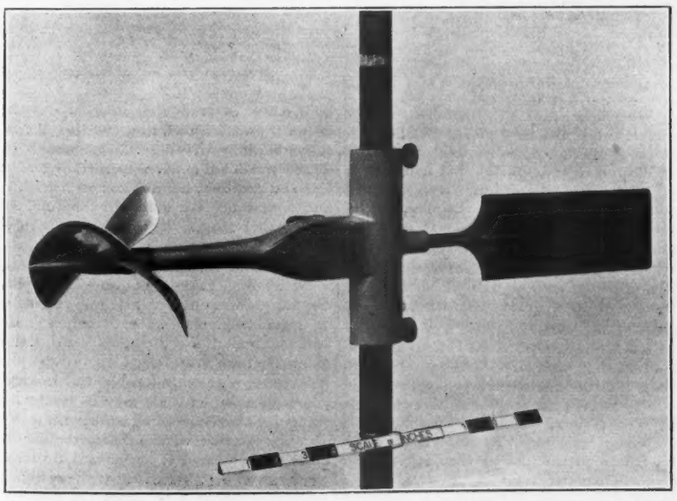


FIG. 2. THE 1915 MODEL AMSLER FLOW METER.

The meter shown in Fig. 2—the 1915 model Amsler, made by Messrs. Amsler and Co., Schaffhausen, Switzerland—is typical of a considerable number of screw or propeller type meters made by various makers in Europe and the United States. It consists essentially of a two-bladed screw of cast aluminium, revolving about a horizontal axis and carrying with it an axle which runs in the body of the cast aluminium meter frame, with a hard-steel ball bearing at the forward end and a hard-steel pivot bearing on a sapphire and acting as a thrust bearing at the rear end. The axle drives a worm gear, which once in every 50 revolutions of the meter rotates a cone in an oil-filled chamber and so allows a contact spring to send an electric signal. The meter has a vertical tail, and is fixed with clamping screws, as shown, on a 1-in. cylindrical rod.

Another form of propeller meter—the Stoppani, made by Messrs. Stoppani and Co., Berne, Switzerland—is shown in Fig. 3. It is distinguished from the other type by a provision against the effects of oblique currents. The measuring system is a three-bladed propeller carried on a horizontal axle, which runs on rustless steel pivots, and through a worm gear rotates a four-bar commutator forming part of the signal circuit. The commutator rotates once for each 100 revolutions of the meter, and with all four bars in thus gives a signal every 25 revolutions; but by cutting out either two or three of the bars it can be arranged to signal every 50 or 100 revolutions. The contacts are freely exposed to the water, having only a loose guard against mechanical injury. The propeller runs inside a guard ring, which shields it from the effects of oblique currents as well as from floating debris. The instrument is attached to an oval steel rod held by a cast-iron support, which is fixed on a rigid platform above the water surface, a spring clamp controlled by a pedal on the support serving for the adjustment of the meter in any desired position.

A considerable amount of work which has been done on these and similar meters is described in a general report on rating current meters. The method of rating is to tow the meter under test at various speeds through still water, observing the speeds of towing and the revolutions of the meter per second or per foot. The curve obtained by plotting speed of towing against revolutions is adopted as the calibration curve of the meter, by which its speed is translated directly into the velocity of the stream in which it is used. The effect of the tests described is submitted as showing that, in spite of the material extent to which current meters are affected by the circumstances in which they are used, their measurements are reasonably accurate at velocities of not less than $\frac{1}{2}$ ft. per second and in water that is not very disturbed or turbulent. In particular, it is regarded as establishing the validity of the assumption, fundamental in the use of all these meters, that the velocity of water moving through a meter at a fixed point can be measured by the use of a calibration curve obtained from the same instrument moving through still water. The laboratory experiments made for the Committee were addressed to particular points in the design, workmanship and circumstances of rating of the meters illustrated above, and to some extent of others of somewhat similar design. The Froude tank, in which the National Physical Laboratory experiments were made, is 595 ft. long by 30 ft. wide by $12\frac{1}{4}$ ft. deep; the channel for rating current meters at the Imperial College is 100 ft. long by 5 ft. wide by $3\frac{1}{4}$ ft. deep. A number of ratings of the same meters in both channels established the fact that the ratings in the small channel of the meters under oblique velocities were misleading. Another disadvantage of the College tank for some measurements is that it is far less convenient for obtaining a steady motion. The Froude tank has an electrically-driven carriage for towing the objects under test, the electrical arrangement being such as to give a very constant motion to the carriage and admit of wide speed variations. Meter readings, distances, and times are also recorded electrically and automatically. In the College tank the meter is towed from a hand-pulled truck, and not only is the motion somewhat jerky but also the velocity has to be controlled by stop watches or other indirect means. At the same time, the carriage of the Froude tank, having been designed for testing ship models, cannot give a lower speed than 0·6 ft. per second, and observations on lower speeds had therefore to be made in the College tank.

A number of graphs are given recording some of the observations made in the two tanks, together, in some instances, with similar observations made in Switzerland. A number of discrepancies between ratings of the same meters were discovered, but in normal ratings none that was serious was found between the results of the Froude tank and the College channel. Except for low speeds and oblique velocities, the rating in the Froude tank was from 0·2 per cent. to 0·45 per cent. higher than in the channel for the same velocity. The Price and Amsler meters gave sufficiently good results at velocities down to 0·5 ft. per second, and the Stoppani down to 0·75 ft. For oblique ratings the error caused by obliquity in the small channel was considerable, and the ratings in the large channel were assumed to be correct. On these the Stoppani showed a maximum error of ± 5 per cent. through oblique flow, as against as much as — 25 per cent. in an unshielded screw meter such as the Amsler; the Price meter was not tested under oblique flow, as by previous results it was known already to read considerably higher under those conditions. The results with oblique velocity apply, of course, to turbulent flow, though errors tend then to balance each other rather than to cumulate. The advantage of the Stoppani meter in the presence of oblique

velocities is attributed to the guard ring, which shields the edges of the propeller blades and guides the water through them.

An important series of tests was made at the Imperial College on a Stoppani meter with the object of investigating the method proposed by Mr. E. H. B. Wade to the Egyptian Ministry of Public Works for driving a meter normally with a constant force independent of the flow, the external force overcoming all systematic resistances in the instrument, and leaving the effect of the stream to appear by an increase or reduction of the speed at which the meter revolves. This arrangement was intended specially for use with low velocities, when with previous methods the effect of instrumental resistances must be relatively considerable. The driving force used was a falling weight. The results led to the conclusion that, while the principle of driving the meter by an external force to overcome friction was sound, the use of a falling weight for the purpose was not likely to be satisfactory. Dr. Hogan has proposed an electric drive, in which the speed of the meter should be kept constant and the power used to keep it so be taken as a measure of the water velocity. Since the report was in the press Mr. Wade has moreover described a new instrument, which gives a linear rating curve down to a velocity of about 1 cm. per second. Among the most notable discrepancies was a considerable difference in rating between what was obtained by towing in still water and by exposure to a stream of known velocity. Similar differences had been observed with Price and Amsler meters with velocities up to 0·6 ft. per second; above this, however, no sensible difference was found between still and moving water ratings.

A separate part of the work that the report describes consisted of field observations, made partly with the general object of gaining in actual practice some idea of the comparative accuracy and facility with which various current meters can be used, and partly to test the stage-discharge curve method of measuring river flow.

The report describes and discusses the various methods of supporting meters and of making measurements of discharge with them, and it also gives details of arrangements actually used in the field work. Among these are a suspension cable gear erected at Bewdley and a much simpler one at Burgage Bridge. Fig. 4 is a sketch illustrating the Bewdley arrangement, and Fig. 5 detailed views of its various parts. For low flow, boats can be used, but when the reading exceeds 6 ft. they become unsafe, and as every year gauge readings up to 9 ft. occur, with occasional floods raising them to 12·5 ft., a suspension cable across the river was necessary, which considerations of navigation could not allow to be permanent, even if the additional cost had been thought worth while. Accordingly a pair of posts formed of steel channels 10 ft. long, of which 2 ft. 6 in. are bedded in concrete, have been fixed on opposite banks 210 ft. apart, and stayed on the shore side and up stream with angles, also bedded in concrete. A main cable of galvanised flexible steel wire connects the tops of the posts and carries a traveller, consisting of a 2-in. cast iron travelling pulley, which runs on the main cable, and a 4-in. hardwood pulley for the meter cable, each with $\frac{5}{8}$-in. brass bushes screwed in, running on rustless steel axles of $\frac{1}{2}$-in. diameter. The sheaves of the pulleys are of $\frac{1}{2}$-in. steel strips, one of which for convenience of detachment is secured by wing nuts, and the traveller cable is made fast to a bolt midway between the two pulleys. A winch with a spring catch to hold it in any desired position, is fitted on the left-hand post, and carried 210 ft. of galvanised stranded steel wire $\frac{1}{8}$ in. diameter to operate the traveller, with a series of graduations made by binding on fine copper wire and soldering it every 10 ft. On the other post a more elaborate winch is provided for the meter cable, which must be insulated from earth. The cable is connected to a brass strip fixed on one flange of the drum, and the current is collected from this strip and transferred to the telephones. The meter cable is a bare stranded steel wire $\frac{1}{8}$ in. diameter, to avoid the considerable pull caused by a heavy insulated cable; an insulated lead connects it with the contact box, and the return circuit is through the meter body and the water to an earth—an old bucket or biscuit tin—on the bank. With this arrangement a battery giving about 4·5 volts is used instead of the single dry cell that is sufficient with insulated wires. Other details will be apparent from Fig. 5. To get the cables across the river a 3-ply hemp line was sent across from the left bank to the right by means of a rocket, one end of the meter cable being drawn across by this line, and the meter cable and winch were used to draw over one end of the main cable, with its pulley and one end of the traveller wire. The other details of the arrangement will be seen from the figures. In operation the graduated traversing wire paid out by the winch gives the position of the verticals on which depths are to be taken and measurements made, and a metal tape clipped on the meter cable shows the soundings (for which the sinker of the meter is used) and the depths at which current measurements are made. The feel of the winch, together with the sag of the main cable, enables contact between the sinker and the river bottom to be perceived within an inch.

At Burgage Bridge some measurements were made by wading, but a simple cable gear was needed for the higher flows. The stream is normally 65 ft. wide, but in ordinary floods increases to 80 or 90 ft. and in extreme floods to perhaps 300 ft. At this station communication was established between the banks by slinging over a line with a 1-lb. bolt on the end; this then travelled across with a $\frac{1}{16}$-in. diameter stranded steel traversing cable, which in turn brought back the main cable and the light line. The main cable is a $\frac{1}{16}$-in. diameter galvanised stranded steel cable, 80 ft. long, carried on iron posts, 3 ft. high, fixed with pegs and guy lines on either side of the stream; it is attached to the post on the right-hand bank, and is joined to the post on the left-hand bank by a 4 : 1 tackle, through which the tension is adjusted. A pair of $1\frac{1}{4}$ in. galvanised pulley blocks serve as traveller, one running on the main cable, and one carrying the meter cable. The main cable is graduated in 5 ft. sections by insulation tape markings, and the traveller is hauled to coincidence with these. The meter cable is of double insulated cabtyre workshop flex. Depths to feet and half-feet are marked on it with white tape, and soundings are made by reading these marks from either bank. In operation the meter cable is held by the operator, while the traversing cable is wound round a peg during the work on each vertical.

Both for soundings and for plotting-stage discharge curves an accurate and convenient method of measuring the water level is indispensable, and particulars are given of methods and instruments that are available. An automatic continuous recorder is always preferable, but in view of its expense an ordinary scale may be used where circumstances make its reading sufficient, as for instance on a large river with a fairly regular flow. Thus at Bewdley cast-iron sections 3 ft. long are used, with marks 0·02 ft. thick at every tenth of a foot projecting about $\frac{1}{4}$ in. from the face of the scale, which is 5 in. wide by $\frac{1}{4}$ in. thick, and is graduated by brass number plates screwed on. Three such scales are screwed on to a 3 in. by 7 in. timber, cramped to a vertical wall; though as a support an old rail or other metal standard would have been better. On the Liffey a recording gauge is used. These instruments consist essentially of a float rising and falling with the water level, and a recording mechanism registering its movements. The float works in a well, which communicates with the river, so that the levels are the same; it must be large enough to prevent the float from fouling its walls, and so protected as to avoid interference from floating débris. Fig. 6 shows the arrangement adopted for its installation.

(To be continued.)

Fig. 4.

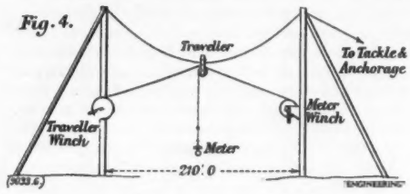


Fig. 6.

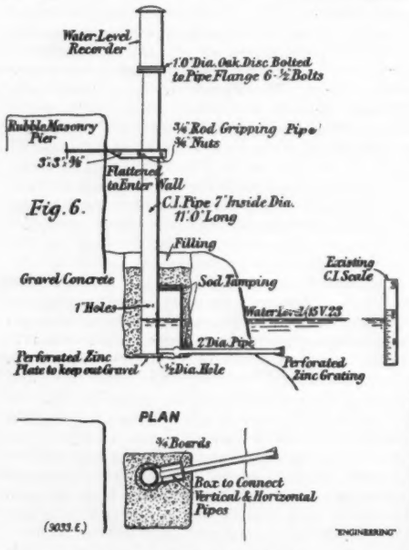
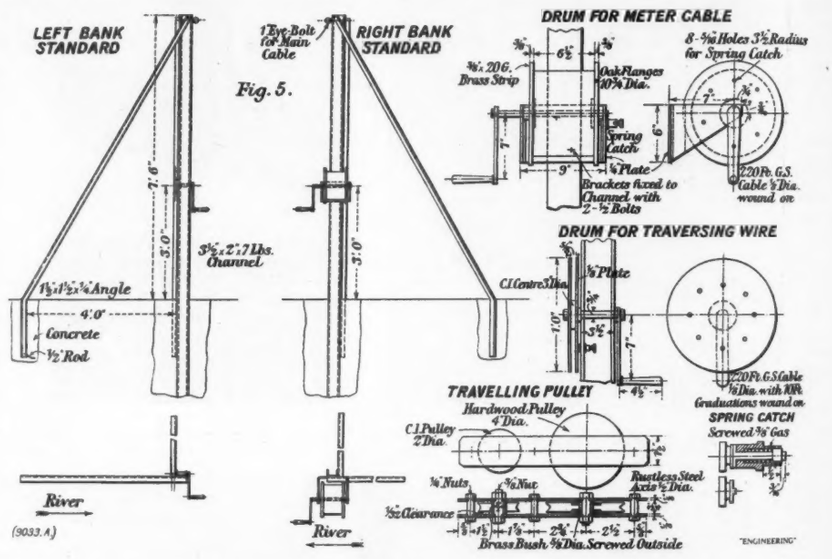


Fig. 5.



NOTES ON NEW BOOKS.

FOR 63 years, daily observers have been busy measuring the quantity of rain that has fallen in their immediate neighbourhood, and since their number has steadily increased, there is now an army of 5,000 devotees meticulously measuring the total drops deposited in various forms of gauges. And if we carry our vision a little further, we can see an organised body collecting the scattered reports of the observers, examining, digesting and criticising the results, and finally compressing them into one small chapter in the fascinating story of an endless cycle of evaporation and condensation. The details are to be found in the volume "*British Rainfall*, 1923" (published by H.M. Stationery Office, price 15*s.*), but the magnitude of the forces at work we shall never grasp, for meteorologists tell us that rain and snow of the weight of 16 million tons are falling on the globe as a whole every passing second. Surely, it is worth while to learn how these forces operate, what is the character of the work they achieve, how it is distributed and what is the probable amount of variation against which agriculturists and economists have to make preparations. Carefully compiled tables tell us much, and ingeniously constructed maps convey to us a vast amount of information that cannot be put into smaller compass or made to tell the tale more succinctly. In every part of the kingdom, the quantity of precipitation for 1923 was greater than might have been expected, and an analysis shows that the stations with the higher percentages were in the districts that are normally wet, while those with lower percentages were in the dry districts. As the wettest districts in this country are among the mountains, the influence of a high level on rainfall is very clearly shown, and, indeed, is more marked than in any year since 1868. This leads to many speculations that we should like to follow, and none is more alluring than that as to the possibility of cycles in the recurrence of periods of wet and dry years. But we can do no more than refer to a very interesting paper by Mr. J. Glasspoole, constituting Part IV of this volume, in which much statistical data are exhibited, and the general position of the question is clearly and impartially discussed.

The electrical trade has grown so extensively that it is essential that the directories which are available must be large if they are to contain the information relating to manufacturers of the different types of plant, which is sought for by the user. An excellent example of a work of the kind is "*The 'Electrician' Electrical Trades Directory and Handbook*, 1925." This is published by Messrs. Benn Brothers, Limited, of 8, Bouverie-street, London, E.C. 4, at a price of 25*s.* net, and, within its compass of 1410 pages, contains an alphabetical list of electrical engineers of all types, relating to Great Britain and Ireland, the Colonies, Continental countries, and the United States of America. There is also a classified section dealing with specific types of manufactures. This publication, familiarly known in the electrical profession as "The Blue Book," contains, within the handbook section, valuable data relating to materials and standards, and gives full information on the legal aspects of electricity supply and use in many different classes of work. It is only necessary to state that the high standard set up with the earlier editions has been maintained and that the matter has been enlarged and brought thoroughly up to date for the new edition.

The theory of centrifugal pumps is one of the problems which are being remodelled in the light of modern research on turbines and aircraft. Dr. Ing. C. Pfleiderer, professor at the Technical High School of Braunschweig, bases his "*Kreiselpumpen*" (Berlin: Julius Springer; price 22·50 gold marks) chiefly on the streamline theory, but he discusses rotary pumps also from the standpoint of the modern circulation theory. The volume of 395 pages is very well illustrated, and is full of references to quite recent work. He points out that the calculation of volute casings must not proceed on the assumption of a mean velocity for the varying cross-sections of the volute, and deals fully with the various ways in which axial thrusts can be balanced. He also shows, and supports by experiments, that the capacity-lift curves, which he calls throttle curves, are all in accord for any particular pump, although he does not take the clearance loss of water into consideration; approximately this agreement should also hold for pumps provided with guide-blades. After having stated the general laws of the flow of fluids and the theory of centrifugal pumps, and discussed their parts, including bearings, Dr. Pfleiderer proceeds to efficiency relations, characteristics, losses, &c., and then passes to materials, constructional features, and finally, to pump installations. His examples and illustrations of pumps and installations are almost exclusively taken from German practice, although his literature is international. Pump corrosion and erosion by gases, electrolysis and grit is noticed, as also are the limiting factors in the application of centrifugal pumps. But questions of economy are not considered, and there is no alphabetical index, which certainly would have made a good book more useful for reference.

A book which introduces engineers to a novel and powerful method should give ample space to the illustration of new definitions and symbols by numerous examples, geometrical and physical, beginning with the very simplest and building up more complicated cases step by step. The symbolic operations should likewise be carefully illustrated and graded, so that the student has geometrical and physical intuitions sufficiently developed to guide him through the maze of abstract symbolical reasoning. In "*Conformal Representation*"—Lewent and Blaschke, translated by Jones and Williams (Methuen, price 7*s.* 6*d.*)—these requirements are partly met by geometrical illustrations, but no physical applications are given. The first chapter, on the definitions and symbols of complex algebra and their interpretation by means of Argand's diagram, is too brief for the understanding of what follows unless considerable previous knowledge is assumed. In Chapter II are deduced the Cauchy differential relations between the "real" and the "imaginary" parts of the dependent and independent variables. These are also shown to satisfy the two-dimensional form of Laplace's differential equation of the potential. Here again completeness is sacrificed to brevity. Chapter III, which forms half of the book, gives equally brief accounts of the expansion of a function in series within the circle of convergency round a point, and the exploration of the complex plane by overlapping circles of convergence. Later on, the behaviour of a function near a non-essential singular point is added. The bulk of the chapter is given to a graduated set of worked-out special cases of transformation which comes near meeting the ideal. In Chapter IV is attacked the much harder inverse problem of finding the function appropriate to arbitrary relations between the variables. The method of integration round a contour appears with disconcerting abruptness, and Schwarz's method of images is outlined. In Chapter V these methods are applied to the general inverse problem, and lead up to elliptic integrals and other transcendental functions. The intention is clearly to suggest only the numerous important developments. Conformal representation offers an unlimited number of two-dimensional solutions of Laplace's equation in electricity and magnetism, in elasticity and in hydrodynamics, and in every branch of physics in which Laplace's equation in two dimensions appears. No doubt the results may be obtained by equivalent methods, but in power, directness, and generality the notation and operations of complex algebra are incomparable. It is well worth sustained effort to learn the use of so valuable an instrument, and this book, supplemented, perhaps, by judicious coaching over the harder steps, may well furnish the necessary direction to engineering students.

Antimony and bismuth resemble one another physically and chemically, but not as regards their ores and occurrences. Antimony is mainly found as the sulphide stibnite Sb_2S_3 and the oxide and native metal are sometimes products of the sulphide. Metallic antimony was well known in ancient times in the East, and, in the Middle Ages, was used for medicinal purposes and also as type metal in Europe. The Benedictine monk Basilius Valentinus, of Erfurt, about 1400, described the reduction of the metal by means of iron in his "*Triumphwagen des Antimonium*." That manuscript may have been a forgery of later date, but some of the processes mentioned were certainly known in his time. According to the "*Antimony Ores*" of Mr. Edward Halse, of the Imperial Institute, the world's production of antimony ores was 17,302 metric tons in 1921 (about a fourth of that of 1916), the chief sources being Southern China, Burma and the Shan States, Western Australia, Borneo, France, and Austro-Hungary. The utilisation of antimony compounds as pigments (red and yellow), mordants and oxides, is increasing; the oxides make good white enamels which are fairly moisture and sulphur-proof. Metallic antimony (antimonial black) gives paper and pottery a steely appearance. The chief alloys with tin, copper, and other metals are Britannia metal (for table ware) and white bearing metal; the copper imparts the hardness. In the lead-antimony alloys, the antimony is the hardening agent and makes the alloy expand on solidifying, which are important properties for type metal, bullet lead, battery acid chamber lead, &c. Bismuth, often confused with antimony and other metals in the Middle Ages, occurs chiefly as native metal, further as oxide (bismuth ochre) and sulphide (mostly in quartz gangue), and associated with copper, tungsten, cobalt, gold, &c., but not with antimony. The dressing of the complex ores, which are prone to premature sliming, is difficult. In "*Bismuth Ores*" Mr. Robert Allen estimates the world's production of the ore and metal in 1921 at over 500 metric tons, supplies coming chiefly from Germany, Spain, Bolivia, and the United States; the bismuth contents of the ores are often low and vary greatly. The chief applications are medicinal, as enamel, and as alloys of low melting-points with tin, cadmium, mercury (liquid amalgams), and other metals. The many bismuth alloys with cadmium are less brittle than other alloys; all Bi-Sb alloys, especially those of equal proportions, expand on solidifying. An alloy of one part of Bi, three of Pb, and two of Sn makes a metal-glass cement. The two publications mentioned [London: John Murray; prices 5*s.* and 3*s.* 6*d.* net, respectively] are, like other monographs of the Imperial Institute, full of statistics, recent references to applications and useful information.

The promotion and extension of trade within the Empire is a question the importance of which needs no emphasis. "*The Empire Commercial Guide*" is the first edition of a year book which has been compiled with the object of providing merchants and manufacturers with concise and readily accessible information upon the commercial and industrial life of all our overseas possessions. Edited by Mr. W. C. Hart-Saxby, and published by the British Commonwealth Trade Press, Limited, 212, High Holborn, London, W.C. 1, the price of the book is 1 guinea net. The subject matter is sub-divided into several parts, each dealing with a continent, and all the dominions, protectorates and colonies are treated in turn. The compiler has spared no efforts to make his information complete, and all matters likely to prove useful to commercial men have been included. Special attention has been paid to questions relating to business intercourse, such as transport, shipping, and banking facilities. The best channels through which trade may be carried on are indicated, and advice and instructions given to intending commercial travellers and manufacturers' agents. All the statistics quoted emanate from official sources, and accuracy of data has been the aim of the editor. The book consists of some 400 well-printed pages, and is of handy size. The object in view is entirely praiseworthy, and this fact, coupled with the undoubted merit of the work, entitles it to a full measure of success.

In the preface to his "*Theorie und Berechnung der Eisernen Brücken*" (Berlin: Julius Springer, price 9 dols., bound), Dr. Ing. Friedrich Bleich speaks of the double task he had to undertake if he intended to let his exposition of the theory and calculations of iron bridges follow a critical survey of the theoretical and experimental bases upon which methods of bridge design have been built up. But the author, a Vienna engineer, does not give a historical review, though he has had, in several instances—notably in the case of the crippling strength of members under compression, the nature of which is still misunderstood occasionally—to go back to the fundamental researches and the original formulæ. Euler's formula of 1744, which concerns the labile equilibrium between external and internal stresses, has been misinterpreted as if it were dealing with bending stresses in stable equilibrium. Dr. Bleich adopts the standpoint of Kámárn in his exposition of these problems, and as regards the crippling strengths of struts of variable cross-section and of braced members he follows the method of Ritz as simplified by Timoschenko. The last four of the eight chapters of his book of 581 pages, deal with local stresses of structural parts, riveting and bolting; with bridge floors; with the chief members, girders, unbraced frames (Vierendeel girders), &c.; with wind and cross bracing; and with bridge bearings and joints. With these main divisions the customary classification of bridges as of the beam, arch and suspension types loses its primary importance, and these structures are discussed in sections of the sixth chapter. Dr. Bleich issues a warning against attaching undue importance to secondary stresses. This will meet with approval; but he uses in this discussion the term *träger* (generally meaning girder) also for tie-bars. His references to experiments on the distribution of pressure over plates of varying sizes are hardly up to date. While drawing attention to recent comparative experiments on finished railway bridges and laboratory researches, conducted chiefly in Switzerland, Germany and America, he does not fail to point out the need for further elucidation of many problems by experimental work. He does not illustrate any finished bridge, nor does he appear particularly to refer to famous bridge failures. He makes numerous quotations from the detailed legal regulations as to the strength of parts in force in Austria, Germany, Sweden, Switzerland, &c., and works out examples of calculations. Dr. Bleich has discharged his task in an original, very able and comprehensive manner.

THE STRUCTURE OF LIGHT.

ON Thursday, May 7, the first of the annual lectures established as a memorial to the late Professor Alfred Henry Fison was delivered in the lecture room of Guy's Hospital Medical School by Sir J. J. Thomson, O.M., F.R.S., Master of Trinity, who had chosen as his subject "The Structure of Light."

His choice, the lecturer said, had been in part governed by the fact that, in the past, the study of light had been characterised by an insight, an imagination, and an ingenuity unsurpassed in any other branch of intellectual effort.

It provided also the best illustration of the vicissitudes of a scientific theory. The problem involved was essentially the transmission of energy through space. We were the pensioners of the sun, and, if this transmission of energy ceased, our own existence would cease also within a very short time. In the 250 years which had elapsed since enough was known about the properties of light to make any serious tests possible, there had, until the last 25 years, always been some theory which seemed, to the majority of the physicists of the time, to give a satisfactory theory of light; it had not, however, always been the same theory.

At the outset they accepted Newton's corpuscular theory, according to which light consisted of particles shot out from lucid bodies at the speed of 186,000 miles per second. Newton's successors and, indeed, his contemporaries, it might be observed, were "more corpuscular" than Newton himself, who held, in fact, that the corpuscle was only part of the light and that it was accompanied by waves in the ether. Newton believed that corpuscles and waves were both integral parts of light. He made use of the ether in his explanation of his "fits of easy transmission and easy reflection" by which he expressed, in the language of his time, that the corpuscles were in a state of vibration, in one phase of which they went through a transparent body, whilst in the succeeding phase they were apt to be reflected.

Each corpuscle of light, he held, was surrounded by waves generated by itself, which in the case of red light had a long wave length and a short wave length in the case of blue light. Hence, according to Newton, light consisted both of waves and corpuscles. He hoped, the lecturer proceeded, to show that a similar view as to the nature of light was suggested by recent investigations. On this theory, the energy involved was concentrated into small packets and was not spread uniformly throughout space.

The purely corpuscular theory of light lasted unchallenged for nearly 100 years, and, throughout this time, grew continually in favour as its consequences were developed by mathematicians, amongst whom Laplace and Poisson were especially prominent. It was not till the end of the eighteenth century that a successful attack was made on it. Then Thomas Young in this country, and Fresnel in France, brought forward an alternative. Young was a man of as many activities as Leonardo da Vinci. He was a great physicist, a prominent physician, and a famous Egyptologist, having, amongst other feats, deciphered the Rosseta stone. In his scientific writings, however, he was so concise that very few could understand him. To Young we owed the principle of interference and the idea that the vibrations of light were transverse to the direction of propagation.

Interference was a phenomenon of such vital importance that a few words must be said about it. Young said that light consisted of undulations spreading out from a luminous body, as waves spread over a pond, the characteristic of which was that similar conditions were repeated at regular intervals—the wave-length or the distance between successive crests. If there were two sets of waves one of which reached a point directly from the source whilst another set only did so after reflection from the bank; then, if at the point considered the two crests or the two troughs coincided, there would be a very great displacement of the water, whilst if the trough of one set coincided, at the point considered, with the crest of another, there would be, at this point, no disturbance of the surface. This condition would occur when the length of the path travelled by the reflected wave exceeded that of the direct wave by an odd number of half wave-lengths. At all points where this occurred we had dead water and no energy, whilst if the paths differed by an even number of half wave-lengths the displacement was doubled. We thus had a series of places in which there was no energy, separated by places where the energy was great. In this way we got concentrations of energy instead of a uniform distribution. The energy therefore flowed along definite channels, and in such cases we got a fan-like spread of lines of greater energy separated by lines in which there was none. This effect was well shown in Fig. 1, which was reproduced from a photograph of a surface of mercury showing the interference of two sets of waves.

A corresponding condition arose when light was passed through a small orifice, and he owed to Professor Hofford the photograph reproduced in Fig. 2, which represented the diffraction rings then observed. In this case it would be seen that, instead of uniform illumination, we got a series of dark and light rings.

Interference, the lecturer continued, did not destroy energy, but merely moved it from one place to another. Young originated this fundamental idea, but its mathematical and experimental development was mainly due to Fresnel who used it to explain polarisation and double refraction. Fresnel, moreover, predicted some most unexpected phenomena, all of which were, however, realised in experiment, not merely generally but quantitatively. This was the more striking because experiments in optics were more accurate than in any other branch of physics.

Up till the end of the 19th century, no physical theory had come through such severe tests as had the undulatory theory of light. On this theory the energy of light was not concentrated into "bullets" like the corpuscles, but was spread continuously through space. Here was to be found the source of the trouble which commenced 25 years ago in connection with Röntgen rays. These rays were a very potent form of light and had the same physical nature. They gave pronounced electrical effects, and the results, observed were, to put it mildly, not what we should expect from the undulatory theory.

The Röntgen rays, when passed through a gas, caused the molecules to eject electrons. We had accurate methods of counting these electrons, and it turned out that, even after a very prolonged exposure to the X-rays, not as many as one molecule in a million million had lost an electron. On the undulatory theory all the molecules were exposed to identical conditions. Why, therefore, had only one in a million million suffered change?

The phenomenon was intelligible on the corpuscular theory, but was not easily explained on the undulatory theory, and the speaker, at the date named, had accordingly made the suggestion that light must be considered to consist rather of bright specks on a dark background than of uniform illumination.

Moreover, when Röntgen rays or ultra-violet light fell on metals, electrons were ejected at a speed which could be measured. If the ejection were due to the light it would be expected that the speed would be less the fainter the light, but this was not so. The speed with which the electron came out depended solely on the wave-length of the light and not at all on its concentration. With a strong illumination more electrons were ejected, but the speed was the same as with very faint illumination. This speed was higher the shorter the wave-length, and varied only to a minor extent with the nature of the metal.

These results were difficult to reconcile with the undulatory theory, but were quite in accord with the corpuscular theory, since a corpuscle would have the same energy however far it had travelled before striking the metal plate.

Another difficulty was brought forward by the late Lord Rayleigh, who showed that if the undulatory theory were true, and if we accepted the molecular theory of gases, then the colour of a body should be independent of its temperature. As a matter of fact we knew that if a metal were heated, its colour changed from red through yellow to white. This discrepancy with theory had been investigated with great success by Planck, who showed that the observed variation in the kind of radiation with rise of temperature would occur if the energy of the radiation was atomic in character—done up into small parcels of which any atom it encountered had either to absorb all or none. Planck also showed that the energy in these parcels must be inversely proportional to the wave-length or directly proportional to the frequency, being given by the product $h\nu$, where ν denoted the frequency, h being known as Planck's constant.

This, again, threw great doubts on the completeness of the undulatory theory; indeed all the electrical phenomena in question pointed to a corpuscular theory, but this was helpless to explain interference. The conflict between the two theories might be regarded as analogous to a combat between a shark and a tiger. Each was supreme in its own element and helpless in the other. The corpuscular theory dealt satisfactorily with all the electrical effects of light, but not with the optical, whilst the undulatory theory was most satisfactory in optics, but failed to account for the electrical properties.

As it was these electrical properties which threw doubt on the sufficiency of the undulatory theory, it was natural to turn to the electro-magnetic form of this theory which had been originated by Maxwell.

As was now common knowledge, there were many contrivances by which we could excite electric waves. Fifty years ago Maxwell solved the problem as to what ought to happen if one of these exciters acted. He showed by an extension of the laws of Faraday and Ampère that electric and magnetic forces would rush out into space with a velocity which could be calculated from purely electrical data and he found that, thus calculated, the speed was the same as that of light. This was a remarkable coincidence, and the natural interpretation was that light itself consisted of electro-magnetic waves.

Maxwell's work was entirely theoretical and we had to wait a long time before methods of directly producing and detecting electro-magnetic waves were devised. This was, at length, accomplished by Hertz and Lodge, and the electro-magnetic waves were then found to possess the properties of light. They could be reflected, refracted and polarised, and differed merely in wave-length from the waves of visible light. The wave-lengths, in fact, measured feet or miles in place of small fractions of a millimetre, but, on the other hand, the instruments used in generating or detecting them were millions of times larger than the atoms or molecules concerned in the emission of light.

This theory of Maxwell gave a definite conception of what light was, viz.: lines of electric and magnetic force at right angles to each other and travelling, with the speed of light, in a direction at right angles to both. Maxwell only introduced physical quantities we were in the habit of measuring, and the equations he established were the same as those of the undulatory theory.

In Fresnel's equations, a certain symbol appeared which represented the "nominative of the verb to undulate." The question naturally arose: What was this nominative? and it did seem that Maxwell had found it.

Maxwell's theory, however, involved the even distribution of energy in space, and, in this regard, it had no advantage over the original undulatory theory. The speaker accordingly proposed to make an addition to it, which seemed to promise the possibility of explaining both electrical and optical effects.

As a preliminary, he would ask what the position was, if we gave up the undulatory theory and tried to explain everything in terms of the quantum of light. We knew that these quanta all travelled with the same velocity, although the energy in some was a millionfold as great as it was in others. This was difficult to explain. Experiment, moreover, showed that the ambit of the quantum was very great. One instance of this was the well-known fact that in the very middle of the shadow of a solid disc we got a bright point of light, if the source

were properly placed. This experiment was of special interest, because when Fresnel submitted his paper to the Académie des Sciences, Poisson disposed of it, by remarking that if the theory were true there should be a bright point in the shadow of a disc. This he regarded as an obvious absurdity. The experiment, however, was tried and Fresnel was proved to be right.

In illustration of this the lecturer gave Fig. 3, which is reproduced from a photograph of an aperture taken by light which had passed round a 2-in. steel ball. A little wire-work pattern was arranged in the aperture and could be seen in the reproduction. A photograph of President Wilson, the speaker said, had been taken in the same way. In order to get such results the quanta must be as big as a football, but such quanta were useless from the electrical point of view. He proposed therefore to make an addition to Maxwell's theory which seemed helpful.

Lines of electric force were lines drawn in the direction of the force at each point. A series of such lines between a unit of positive and a unit of negative electricity was represented in Fig. 4. Each, it would be seen, started from the one electrified body and ended on the other. In this type, each line was therefore anchored to a positive charge at one end and to a negative charge at the other. The velocity of a line in this condition might be anything, since it had to drag heavy bodies along with it. There were other types of lines of force, as, for example, the lines of magnetic force, which existed round a wire conveying a current. These lines were closed circles. We might similarly have closed rings of electric force, and these rings, being then self-contained, travelled in a direction at right angles to themselves and at a definite speed, which was that of light. He made the assumption that when an atom emitted light there were two distinct lines of force involved. The one type was that discussed by Maxwell, and the other was peculiar to the way in which light was generated. This latter was a closed line of electric force. If such rings moved forward at right angles to their plane, they would fulfil Maxwell's conditions and they would, moreover, not alter in size as they passed through space.

Smoke rings, he might add, also moved at right angles to their plane, and carried with them the air of which they were comprised just as if they were solid bullets.

The method of starting a closed ring of electric force might be as indicated in Fig. 5. In Fig. 5 we had at A a straight line of electric force between the electron E and the positive-charge P. Suppose the electron were displaced so suddenly that the motion was too fast for the line to follow. Such a violent agitation would throw the line of force into a loop, as indicated at B. The closed curve thus produced would then break free from the heavy bodies and travel out into space, as indicated at C and D, like a disembodied spirit, carrying with it the potential energy associated with the displacement of the electron.

In view of the violent agitation attending its formation, the ring would be vibrating, and these vibrations would start Maxwell waves, which would accompany the ring, but most of the energy would be in the latter. This ring contained, accordingly, packed into a form very convenient for transport, potential energy originally distributed around the luminous atom.

The next question that arose was, how was this energy to be got out again? The ring being closed had no external effect. Hence it was not likely to lose energy as it passed through space. To get the energy out, it would be necessary to reverse the process of formation and to break the ring. This might take place, as indicated in Fig. 6. In Fig. 6 at A the ring was seen approaching the line of force between P and E. At B it had joined up with this, and at C and D it was opening out and pushing the two charges apart. To get E right away from P, the energy in the ring must be sufficient to move it to a place from which it did not at once spring back.

If E and P were only pushed a slight distance apart, they would come back again; the ring would be reformed and go on again through space. Hence the atom, in absorbing a quantum of the radiation, had not merely "to hook the fish but to land it." It was not necessary that the electron should be thrust so far away as to leave the atom completely ionised. There might be temporary resting places for the electron, in which it would remain so long as the absorption lasted. It followed from this that when light which could not ionise the atom was absorbed, there must be some allotropic modification of the atom in which the energy content was greater than in the normal state by the amount represented by the quantum absorbed. Thus, modification of the atom was not necessarily permanent; it need not endure even for seconds, but merely for a time which was large compared with the time of vibration of the light.

Water vapour, the lecturer added, had at least three strong absorption bands in the infra-red, and must, therefore, exist in three different allotropic modifications.

It remained to explain how the idea that the energy was concentrated in the ring was consistent with interference phenomena. He had not time to go into the exact logic of it on that occasion, but would merely say that the ring being closed, the outside force was very small, and it moved accordingly, at right angles to itself. If we altered the direction of the force, we should also alter the direction of the motion. When Maxwell waves passed through a small aperture, the walls of this produced strong electric fields, which altered the direction of the lines of force and thus caused the ring to go in a different direction. The direction in which the energy flowed was thus turned away and altered by the electric field of the neighbouring atoms. Though the Maxwell waves accompanying the ring had no energy to part with, and were incapable of absorbing it from the ring, they did direct the flow of the energy, diverting it and guiding it along particular paths.

We could thus explain the distribution of energy in the diffraction of light passing through small apertures. Owing to the action of the electric field of the atoms lining the aperture, the Maxwellian waves coming through had no longer a uniform direction but spread out fan-wise. Now tracing back the paths of energy flowing in any particular direction through the aperture, it would start from

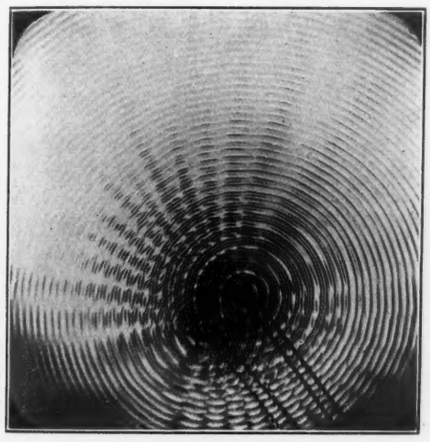


FIG. 1.

FIG. 2.

FIG. 3.

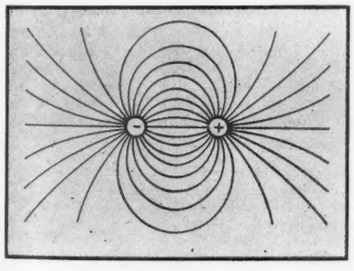


FIG. 4.

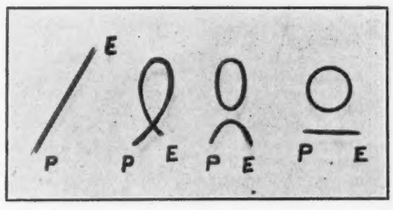


FIG. 5.

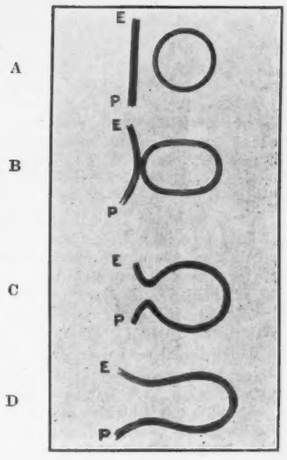


FIG. 6.

some place on the surface of the wave before the wave reached the aperture, and the magnitude of the flow of energy to any place through the aperture would be proportional to the area of the surface of the incoming wave which sent energy to that place.

The chance that the ring was just behind any particular spot on the incoming surface was proportional to the area of the surface, and, as it followed the flow of energy in the wave, the chance that it arrived at any point P through the aperture was proportional to the flow of energy through P, calculated on the undulatory theory. The phenomenon is now a statistical effect, and if we could see each individual arrival, we should observe that more rings arrived at certain points than at others, thus giving rise to the appearance of the diffraction bands.

The circumference of the ring is equal to the wave-length of the light, and calculation showed that the energy in such a ring would be inversely as the wave-length or directly as the frequency, and was thus in accord with Planck. Different-sized rings corresponded to different types of light. Here was to be found the explanation of certain differences in the effects of light and Röntgen rays. The wave-length of visible light was very large compared with the diameter of a molecule. If the quantum struck a molecule, therefore, only a little bit of it was concerned, and there was little chance of the molecule getting the energy out. In the case of Röntgen rays, the size of the quantum was comparable with molecular dimensions, and the molecules, therefore, easily trapped the energy.

The foregoing had a bearing on the question of resonance. If a wireless receiver were out of tune, it only captured the energy which "naturally" struck its surfaces. When in tune, however (as Lamb and Rayleigh had shown), the energy taken in was not proportional to the size of the receiver, but to an area having a diameter comparable with that of a wave-length. Hence, with wave-lengths of 500 metres, a wireless receiver was taking in energy from an area which was a considerable fraction of a square mile. With the receiver tuned, energy flocked into a system which it found so much in sympathy with it. Similarly, in the case of ordinary light. With a molecule "in tune" with the radiation, the energy of the ring which was spread over an area the diameter of which was comparable with the wave length, could be concentrated into the volume of the molecule, which would thus have a good chance of absorbing the radiation.

In the case of visible light, the absorption was quite sharp, because resonance was then necessary, in order to concentrate into the molecule the energy of the ring, which was of larger dimensions than the molecule. This was not so necessary for Röntgen rays when the energy was already concentrated.

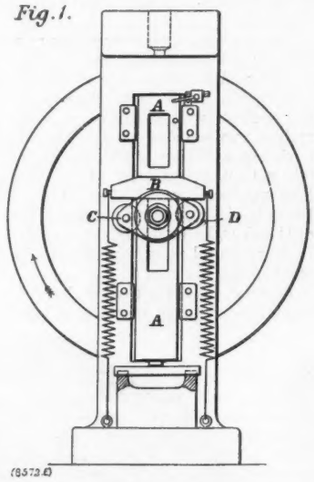
On the view he had put forward light did not consist of one constituent but of two—the ring of electric force and its accompaniment of Maxwell waves.

UNDERGROUND PARKING OF MOTOR CARS.—The rapid increase, in recent years, in the number of private owners of motor vehicles has led to great difficulties in finding suitable garage accommodation, and the problem is especially acute in the larger cities and towns. In the majority of cases, the available accommodation is neither sufficiently extensive nor conveniently situated to meet the demands of those owners who use their cars for business, shopping, and theatre visits. The practice of leaving the car at the kerb-side is objectionable from several points of view, probably the most important being that it increases the danger of the streets by shrouding the moving traffic. The present situation has placed the various authorities concerned in a very difficult position. Even at the present time, the position in many congested areas is only made tolerable by the tact of the police, and it is obvious that it will be much more acute in a few years' time. On this account the suggestion put forward by the Automobile Association that the difficulty should be met by the provision of underground parking places, where no suitable site exists above ground, is worthy of serious attention. It would be necessary for local authorities to obtain powers to raise loans in the majority of cases, but there should be no difficulty in doing this if the Association is correct in its opinion that it would only be necessary to make a very moderate parking charge to render such undertakings financially sound.

ENDURANCE IMPACT TESTING MACHINE.

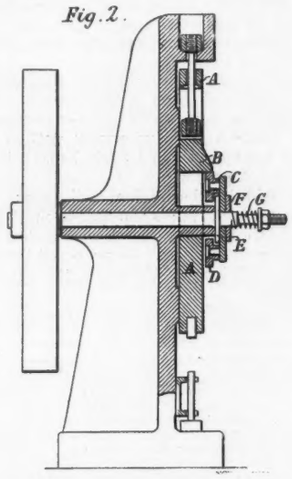
MESSRS. ALFRED J. AMSLER AND CO., SCHAFFHAUSEN, SWITZERLAND.

Fig. 1.



(8573.A)

Fig. 2.



UNIVERSAL ENDURANCE IMPACT TESTING MACHINE.

UNDER modern engineering conditions involving heavy loads and high speeds, the vibratory stresses which materials are called upon to withstand are often of considerable magnitude. The older forms of mechanical testing do not always give sufficient data concerning the physical properties of metals and the importance of a fatigue test, which applies repeated stresses to the test-piece, is now generally recognised. The endurance shown by a material in the fatigue-testing machine is an indication of the soundness of its inner structure, and supplements and completes the knowledge obtained from tensile-strength figures and impact values.

On this page and on page 608 we give illustrations of a machine recently placed on the market by Messrs. Alfred J. Amsler and Co., of Schaffhausen, Switzerland, which is designed for making either tension impact, compression impact, or transverse bending impact fatigue tests. The essential working parts of the machine are shown in the diagrams, Figs. 1 and 2. The hammer A with cross-head B is vertically guided by ball-bearing rollers and is provided at its lower end with a cylindrical steel block which is used in the compression and transverse bending tests. Spring pressure holds the cross-head B of the hammer in contact with two crank-pins C and D. The latter are mounted on a disc which is rotated by means of a shaft and flywheel driven by an electric motor. An alternating-current motor, or a direct-current motor with shunt excitation, gives the crank-pin disc a rotational speed which may be regarded as perfectly constant. The load is uniform, and the flywheel is made of sufficient mass to ensure regularity in operation. For each revolution of the shaft, two blows are delivered by the hammer, and the velocity v of each downward stroke of the hammer is a function of the rotational speed of the crank-pin disc. The kinetic energy ($mv^2 \div 2$) of each blow may be determined from the weight of the hammer m, the diameter of the circle described by the crank-pin, and the rotational speed of the shaft.

The elasticity of the material under test is brought into play, and causes the hammer to rebound after each stroke with an upward velocity almost identical with that of the blow. The rising crank-pin and the cross-head guide will therefore meet at a much reduced relative speed. In order, however, to avoid any possibility of dangerous shock taking place, the crank-pin disc is mounted on a friction device lettered E, F, and G in Fig. 2. The slight lag imparted to the disc in cases of shock has no influence on the downward velocity v of the hammer. The weight of the hammer is 3·5 kg., or about 7¾ lb., and the force of the blow may be varied by increasing or decreasing the speed of rotation of the shaft. The belt operating the latter is driven by a pulley, and for the purpose of varying the speed of the shaft three interchangeable pulleys are provided, capable of imparting speeds corresponding to 350, 500 and 600 hammer-blows per minute, respectively equivalent to 1·08, 2·17, and 3·25 ft.-lb. of kinetic energy.

When the test piece breaks, the hammer descends its full course until it reaches a stop which releases a pawl. The latter falls into a notch on the hammer, which, upon being lifted up once again by one of the crank-pins, remains fixed in its uppermost position. The number of blows delivered by the hammer is registered by means of a counter operated by the crank-pin disc. The stoppage of the hammer breaks the circuit supplying current to the electric motor and the latter comes to a standstill.

For tensile fatigue impact tests, round screwed-end bars are used. The test piece is inserted, through an eye situated at the top of the machine frame and is held in suspension by means of a hardened steel nut. The lower end of the test piece is attached to the upper end of the hammer, as shown in Fig. 6. The slotted bar used to hold the lower main nut in position while the locking device is screwed home, is illustrated in Fig. 7. With each downward stroke, the top of the hammer strikes the nut at the lower end of the test bar and the blows are repeated until the latter breaks. The middle portion of the test-piece is machined down to smaller section so as to prevent breakage occurring within the grip. The dimensions of the test-piece are as follow:—total length 110 mm. (4·33 in.) and free length between the screwed ends 74 mm. (2·91 in.). The screwed heads are provided with a ¼-in. gas-thread, the outside diameter of which is ½-in. (13·1 mm.). Shouldered end tensile test-bars of a similar pattern may be used and the grips used with this form of test-bar are shown in Fig. 8. The machine fitted ready for tensile fatigue impact testing is shown in Fig. 3.

The test bar used in compression impact testing is shown in Fig. 9; it has plane end surfaces and is 70 mm. (2¾ in.) in length. The bar is shown in position in Fig. 4; it rests on a block and leans against a support to which it is lightly held by means of a spring. With each downward blow, the cylindrical block of the hammer strikes the upper plane surface of the test-piece and the process is repeated until fracture takes place.

For transverse impact endurance tests, a cylindrical bar from 12 to 16 mm. (0·47 to 0·63 inch) in diameter and 120 mm. (4·72 in.) long is used; it is shown in Figs. 10 and 11. The test-piece is placed in a horizontal position upon two rests, the edges of which are 100 mm. (3·94 in.) apart, and it is pressed lightly against these rests by means of two springs. The rests may be raised or lowered according to the thickness of the test-piece. Stops at each end prevent the test-piece from sliding longitudinally and the whole arrangement is shown set up in Fig. 5. A pin fixed in a transverse hole at one end of the test-bar fits into the rotating carrier, which, in turn, receives its motion from the main shaft. The bar may either be rotated at a uniform speed or in such a way as to make a half turn between two consecutive blows. In the first case, the blows are evenly distributed over the whole circumference, and in the second, the test bar is subjected to a repetition of alternating stresses.

The base of the machine should be secured by means of four bolts to a concrete block some 28 in. high; the frame of the machine is 27 in. in height. The test-piece is then in a convenient position for observation purposes. The motor and jockey pulley are arranged on a plate secured to the side of the concrete block. The machine alone weighs about 440 lb. and the gross weight of machine and motor amounts to some 660 lb. As can be seen from the photographs reproduced in Figs. 3, 4 and 5 on page 608, the whole machine is very compact, occupying a minimum of floor space.

40-50-H.P. OVERHEAD-VALVE MOTOR-CAR ENGINE.

CONSTRUCTED BY MESSRS. ROLLS-ROYCE, LIMITED, ENGINEERS, DERBY.

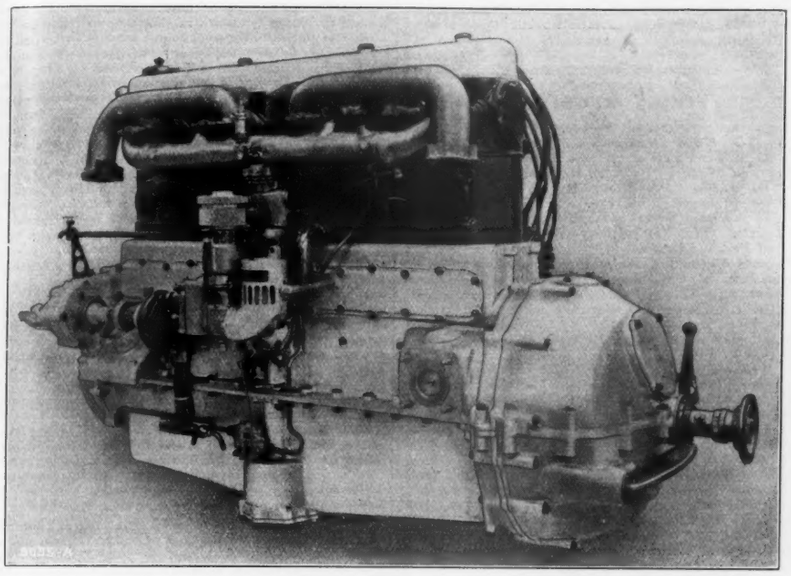


FIG. 1.

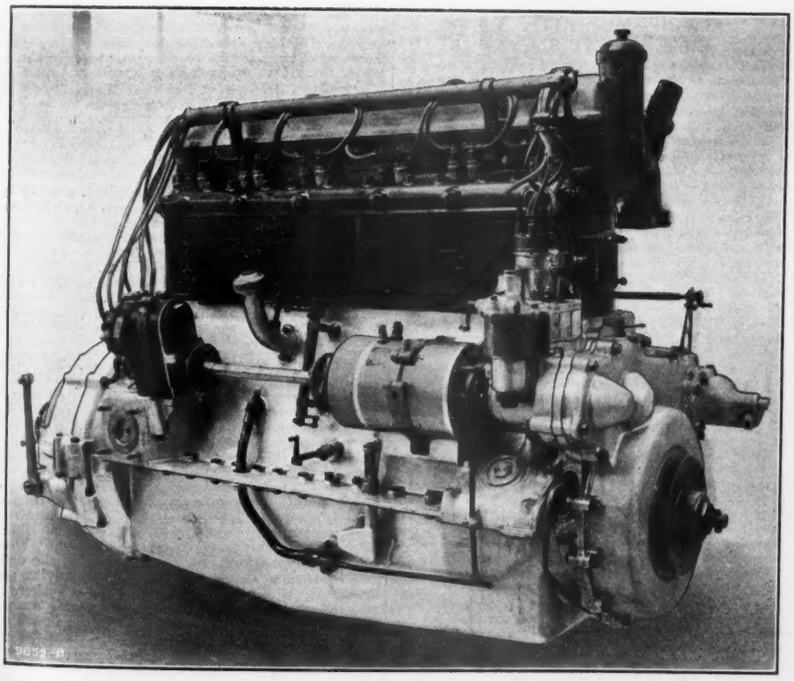


FIG. 2.

40-50-H.P. ROLLS - ROYCE CHASSIS WITH OVERHEAD-VALVE ENGINE.

THE announcement that Messrs. Rolls - Royce, Limited, of Derby, are introducing a new 40-50-h.p. motor-car fitted with an overhead-valve engine is naturally one of exceptional interest. In view of the unique reputation attained by the firm with their side-by-side valve model of this power, the performance of the new car is certain to be watched very closely, and as the lines of the new car are generally similar to those of the old, an excellent opportunity will be afforded of comparing the life, and other characteristics, of the two types of engine. The opportunity for such a comparison is enhanced by the fact that the new model does not replace the well-known 40-50-h.p. chassis, to which we have referred, but is complementary to it. The differences between the two cars as regards the remainder of the chassis are of a minor nature, but the overhead-valve engine is, of course, an entirely new design. It is $4\frac{1}{4}$ in. bore by $5\frac{1}{2}$ in. stroke, the capacity thus being 7,668 c.c. and the R.A.C. rating 43·3 h.p. The corresponding figures for the older engine are $4\frac{1}{2}$ in. bore by $4\frac{3}{4}$ in. stroke, giving a capacity of 7,410 c.c. and an R.A.C. rating of 48·6 h.p. Actually the new engine gives 33 per cent. greater power at 2,250 r.p.m., and it is stated that it can be run at well over 3,000 r.p.m. without the valves leaving the rockers.

We illustrate the new engine in Figs. 1 and 2, on this page, from which it will be seen that many of the features standardised by the makers in their earlier engine are retained. These include the Rolls-Royce standard double-throat automatic expanding carburetter, and dual ignition by battery and magneto. The engine is fitted with a friction-driven fly-wheel damper at the front end, completely enclosed in the half-time wheel casing with all the driving gears. The latter are of the helical spur-wheel type and are driven by the Rolls-Royce special friction damped spring drive from the crankshaft. The engine is carried in the frame on three point suspension, with vibration dampers on each side of the crank-case at the forward end. Pressure feed lubrication is provided to all crankshaft bearings, crankpins and gudgeon pins. Oil is fed, at reduced pressure, to the hollow overhead valve-rocker shafts, and is sprayed on to the teeth of the timing-gear wheels. The camshaft rollers, tappets and driving gear are completely enclosed within the base chamber, and all other parts of the valve mechanism are also enclosed and automatically lubricated with low-pressure oil. The gear-type oil pump is driven from the camshaft by skew gears, and is located in a pocket formed in the lower part of the crank-case. A cylindrical filter completely encloses the pump and can be removed for cleaning by taking off the cover plate.

The valve springs and rockers are enclosed by a readily detachable cover, and the valve clearances are adjusted by eccentric bushes in which the rockers are carried. As will be seen from Fig. 1, the exhaust and inlet manifolds are both mounted on the near side of the engine. The intake branch from the carburettor is jacketed, and petrol traps are provided at each end of the inlet manifold, from which any liquid fuel collecting when the engine is cold is returned through pipes to the main intake. The foot accelerator opens the throttle in the usual manner, but the hand control operates through a centrifugal governor which controls the throttle through part of its total range, thus tending to prevent the engine from racing.

A special feature of the engine is a system of synchronised automatic advance, by means of which both systems of ignition are controlled through a centrifugal governor. The latter is arranged to control the oil supply to a small servo-motor, which gives ample power to operate the various ignition-control levers. The arrangement also constitutes a safety device, because the oil for the servo-motor is supplied from the main lubrication system, and, should the latter fail, the ignition is automatically returned to zero, thus giving warning to the driver. The single-ended water pump, which can be seen in Fig. 1, is ingeniously arranged with a double gland, so that oil or grease can be forced into the sealed space between the two packings, forming an effective water lock. The twelve valves are placed in one line, with the rocker arms mounted in two groups of six. The push rods pass through the head and cylinder block on the near side.

Turning now to the other features of the chassis, the radiator is of the usual honeycomb type, but with tubes of circular section, and is fitted with vertical shutters controlled from the instrument board. A single dry plate clutch is fitted, with a clutch stop of special design. The suspension is by semi-elliptic front, and cantilever rear springs, and four-wheel braking, with two additional brakes on the rear wheels, is fitted. The gear-box is mounted on three-point suspension, and has four forward speeds and reverse. The total overall length of the car is 15 ft. $10\frac{1}{2}$ in., the wheelbase 12 ft., and the track 4 ft. 8 in. An alternative long wheel-base model is marketed with the first two dimensions increased by $6\frac{1}{2}$ in.

LAUNCH OF THE SS. "LINDISFARNE."—Messrs. R. and W. Hawthorn, Leslie and Co., Limited, recently launched from their Hebburn Shipbuilding Yard the single-screw steamer Lindisfarne, a cargo boat having accommodation for a number of passengers, which is being constructed to the order of the Tyne-Tees Steam Shipping Company, Limited. Intended to comply with the requirements of Lloyd's 100 A1 class, the vessel has an overall length of 241 ft., a breadth of 35 ft., and a depth, measured to the upper deck, of 24 ft. A feature of the design is the arrangement of the pillaring in the lower holds and 'tween decks to avoid undue obstruction and consequent breaking of stowage. A double bottom is provided and is used for the carriage of water ballast. The propelling machinery, constructed at the St. Peter's Works of the builders, consists of a set of triple-expansion engines, steam being supplied by two single-ended cylindrical boilers. In addition to the usual feed and circulating pumps, a feed-water filter, a horizontal duplex donkey pump, a ballast pump, and also a direct-acting feed pump, operating in conjunction with a feed-water heater, are installed. A See ash ejector is supplied in the stokehold. The Lindisfarne is the third of a group of four ships ordered by the Tyne-Tees Steam Shipping Company, Limited, from Messrs. R. and W. Hawthorn, Leslie and Co., Limited.

LETTERS TO THE EDITOR.

THE ACCIDENT TO THE R.33.

TO THE EDITOR OF ENGINEERING.

SIR,—In regard to the letter in your last week's issue from Major Teed of the Airship Guarantee Company, I think he overestimates the advantage from the point of view of resistance to be gained by removing the control car from its accustomed position to the nose. Study of the results of model experiments show that the parasitic resistance of the existing type of control car is very small, and I believe the proposed change would—at a speed of 70 m.p.h.—only give an increase of 1 or at most 2 miles an hour. With any mooring system it is obviously undesirable that the first part of the airship to be damaged in the event of an accident—however unlikely—should be the control car, which constitutes the brain of the airship. The position in the nose has the serious disadvantages from the pilot's point of view of cutting out all view aft along the airship, and of removing the possibility of suspending in front of the car a "pennant" to act as a "lubber line" for the navigator.

As regards accidents with the present mooring system, before the break-away in the case of both the Shenandoah and R.33 very heavy rolling was observed, and there seems little doubt that it was this rolling in both cases which overstressed the framework. Both airships were moored by a ball joint which gave complete freedom in roll, and it was the inertia of the airship which prevented it yielding quickly enough to gusts to avoid the strain altogether. If the airship is to be held rigidly on each side of the nose—as is suggested by the Airship Guarantee Company—these stresses will of necessity be enormously augmented, and the danger increased rather than lessened. The weight of the proposed two-armed rotating head—which is estimated by Commander Burney at 18 tons—will also have a high inertia against rapid yielding to side gusts.

It is a little surprising to have "success" claimed for the similar Masterman non-rigid mooring method, since it was found—precisely as one would have expected—to cause such damage to the airship at the points of attachment on each side of the nose as to necessitate the removal of the airship from the mast. It is certainly news that this system has been "adopted" in the United States and Japan, and I personally should be most interested to hear of any non-rigid airship in either country which is, or has been, habitually moored out on the Masterman method.

Yours faithfully,
W. LOCKWOOD MARSH, Lieut.-Colonel
(late R.A.F.).

Hockering Gate, Woking.
May 12, 1925.

SOCIETY OF GLASS TECHNOLOGY.

AT the Annual General Meeting of this Society held in Sheffield on April 22, Col. S. C. Halse was succeeded as President by Mr. T. C. Mooreshead, Director and General Manager of the United Glass Bottle Manufacturers, Limited. To fill vacancies on the Council the following were elected:—As Vice-Presidents Messrs. W. Butterworth, Junr., M.A., and J. H. Davidson, M.Sc., F.I.C.; as ordinary Members of Council: Messrs. B. P. Dudding, E. A. Hailwood, H. J. C. Johnson, E. Meigh, M.B.E., M.Sc., and G. Simpson. Councillor J. Connelly was re-elected General Treasurer, and Mr. W. M. Clark, Ph.B., American Treasurer. Professor W. E. B. Turner, D.Sc., was appointed Honorary Secretary, and Messrs. C. B. Davey and Dennis Roe, M.B.E., F.M.A.A., were elected Auditors. The retiring President, Col. S. C. Halse, took as the subject of his presidential address "The Present State of the British Glass Industry." He pointed out that in certain important branches of the industry the unemployment returns provided no index to the relative state of the industry now and prior to the war. The wholesale introduction of automatic machinery had considerably reduced the number of men employed, whilst the production was simultaneously greatly increased.

At the Ordinary General Meeting which followed the Annual General Meeting, the Society departed from its usual practice of having a series of technical papers. Instead, Professor W. E. B. Turner, D.Sc., at the invitation of the Council, delivered a popular illustrated lecture on "Glass as an Instrument of Human Progress." Professor Turner dealt with his subject in two main sections, namely, the place of glass in extending man's mental horizon and the use of glass in providing protection, comforts and luxury. In the first section he dealt with the vast extent of knowledge gained through the application of the microscope, the telescope, the spectroscope, ultramicroscope, camera and chemical apparatus. The second part dealt with the use of heating and illuminating glass and sheet glass for many purposes and included reference to special spectacle glasses, and Mr. F. E. Lamplough's new "Vita" glass for transmitting ultra-violet light and to its use in hospitals, &c. Reference was also made to the pre-eminent position occupied at present by British-made optical glass.

BOOKS RECEIVED.

United States Geological Survey. Professional Paper No. 134. *Upper Cretaceous and Tertiary Formations of the Western Part of the San Juan Basin, Colorado and New Mexico.* By J. B. REESIDE, JR., and *Flora of the Animas Formation.* By F. H. KNOWLTON. [Price 40 cents.] No. 135. *The Composition of the River and Lake Waters of the United States.* By F. W. CLARKE. [Price 50 cents.] Washington: Government Printing Office.

Ether and Reality. A Series of Discourses on the Many Functions of the Ether of Space. By SIR OLIVER LODGE. London: Hodder and Stoughton, Limited. Price 3*s.* 6*d.* net.

Examples in Machine Design. By G. W. BIRD, Wh.Ex., B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 6*s.* net.]

The "Electrician" Annual Tables of Electricity Undertakings, 1925. London: Benn Brothers, Limited. [Price 10*s.* net.]

Practical Handbook on Electro-Plating, Polishing, Bronzing, Lacquering and Enamelling. Ninth edition. Birmingham: W. Canning and Co., Limited. [Price 4*s.* 6*d.*]

Report of Mining Cases Decided by the Railway and Canal Commission Court under the Mines (Working Facilities and Support) Act, 1923. *Vol. I,* 1923–24. By P. GORDON BAMBER. London: The Colliery Guardian Co., Limited. [Price 26*s.* net.]

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Electric Welding. A Practical Introduction to the Methods, Equipment, &c. By L. B. WILSON. London: Sir Isaac Pitman and Sons, Limited. Price 5*s.* net.

Port Administration and Operation. A Review of Systems of Management in Vogue in Various Countries. By BRYSSON CUNNINGHAM, D.Sc., M.Inst.C.E. London: Chapman and Hall, Limited. Price 13*s.* 6*d.* net.

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The Electrolytic Separation of Magnesium from Magnesia. By ICHITARO NAMARI. Sakai: Ishitara Namari.

Modern Practice in Mining. Vol. I. *Coal. Its Occurrence, Value and Methods of Boring.* By SIR R. A. S. REDMAYNE, K.C.B. Third Edition. London: Longmans, Green and Co. Price 10*s.* 6*d.* net.

The Preservation of St. Paul's Cathedral and other Famous Buildings. By WILLIAM HARVEY. London: The Architectural Press. Price 10*s.* 6*d.* net.

Theoretical and Applied Electrochemistry. By MAURICE DE KAY THOMPSON. Second edition revised. New York: The Macmillan Company. London: Macmillan and Co., Limited. Price 20*s.* net.

Land and Engineering Surveying. For Students and Practical Use. By T. BAKER. Twenty-fourth edition by G. L. Leston. London: Crosby Lockwood and Son. Price 3*s.* 6*d.* net.

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W. 1, announces that the Victorian Government Railway Authorities, in Australia, invite tenders, until July 8, for the supply and delivery of a double recording instrument for use on the lines.—The New South Wales Government Railways and Tramways authorities, of Sydney, Australia, invite tenders, until August 5, for the manufacture, delivery, and erection at the Power House, White Bay, Sydney, of two complete drag-line ash conveyors.—The Napier Harbour Board, New Zealand, invite tenders, until August 10, 1925, for the supply and delivery of two electric capstans, 12 fairleads and one portable crane, either electrically or hand operated. Further particulars regarding these tenders may be obtained from the Department of Overseas Trade.

SAFETY FIRST DEVICE.—A safety first device has recently been designed by the engineering staff of Messrs. J. Lyons and Co., Limited, and fitted to their premises in Hammersmith Road. It consists of a miniature van which runs on rails above the roadway in the exit arch, and which is arranged to precede a van emerging from the archway, and thus afford visual indication of the presence of the vehicle to approaching traffic. The model is illuminated at night, and its movement is accompanied by three blasts from a Klaxon horn. The operation of the device is effected by a nut and screw motion driven from an electric motor. A chained iron with a hinged lid is fitted across the roadway, and the weight of the lorry actuates a switch in a Solenoid circuit. The Solenoid then moves a controller arm to the "outward" contact point, and after a time interval, fixed by a delaying device, the arm automatically returns to the "inward" contact.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Reports received from representative concerns are strikingly conflicting in character. A few of the more favoured lines are disposing of full outputs, but the majority are experiencing quiet conditions, while in the heavy sections there is pronounced depression. No improvement is shown in the state of trade in basic steel, and unless order books alter for the better, it may be necessary to impose further restrictions on production. On the other hand, the call for acid steel is keeping up fairly well. The latest official returns for March last, show that as compared with the previous month, Sheffield's gross production of 94,400 tons of iron and steel fell by 3,800 tons. As compared with corresponding month last year, there was a fall of 18,000 tons. The contraction was mainly in basic steel, which accounted for only 38,000 tons of the total. Similarly, Lincolnshire's output was 20,000 tons less than for March last year. Pig-iron production showed a relative falling off. The railway branches, having completed a large proportion of recently-placed contracts, are working at less than two-thirds capacity, though there is still a good deal of work in circulation in carriage furnishings. The rolling mills are operating intermittently at from half to two-thirds capacity. Orders from the shipping trades are disappointing, but nevertheless call for a substantial output of cranks and shafts. The trend of foreign business in steel products is difficult to gauge, but as far as can be judged, business is notably expanding with South America, and prospects point to a further improvement. Machinery parts are in demand for the agricultural industry, which is also taking substantial supplies of machine knives and other tools. Makers of garden tools are probably as well placed as any, while orders for saws, hammers, and mining requisites are in hand for Australia and South Africa. The building trades are buyers of light castings and ironmongery, while from the automobile engineering industry there is a steady flow of work in magnets and fittings.

South Yorkshire Coal Trade.—The steam coal trade has taken on a somewhat more hopeful tone owing to a slight improvement in the export position. Best steams find an active market on home account, but there is still considerable weakness in secondary grades, coupled with a tendency to accept lower prices for prompt business. Washed fuel is in request on inland account. The prevailing surplus of cobbles and nuts is responsible for a repetition of special offers. The position at house-coal pits has improved despite the weakness of inferior qualities. Quotations: Best branch handpicked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 27*s.*; Derbyshire best brights, 26*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* 6*d.* to 25*s.* 6*d.*; Derbyshire best large nuts, 18*s.* to 22*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; smalls, 3*s.* 6*d.* to 5*s.* 6*d.*

PERSONAL.—Messrs. Ferranti, Limited, electrical and general engineers, of 180, Fleet-street, London, E.C. 4, have removed to new premises at Bush House, Aldwych, London, W.C. 2.—The Pluto Stoker Company, Limited, of 2, Upper Westbourne-terrace, London, W.C. 2, have removed to 27, Chancery-lane, London, W.C. 2.—Messrs. J. F. Crowley and Partners, of 16, Victoria-street, Westminster, London, S.W. 1, have transferred their offices to 11, Queen Anne's-gate, Westminster, London, S.W. 1.

REBUILDING WORN WHEEL FLANGES.—By building up, by means of electric welding, worn flanges of street car wheels in the repair shops of the Detroit Street Railway system in America, an increase of about 20 per cent. in the life of the wheels is expected to be obtained. When flanges are worn to ½ in. thickness or less, the wheels are removed and sent to the repair shop. Here a continuous automatic electric welding machine, a product of the General Electric Company of America, replaces the worn out flange metal in the following manner. Two pieces of welding electrode approximately ½ in. in diameter are kept in constant contact with the wheel at different points where the flange needs building up. Wire is supplied automatically from overhead coils, the contact and feed being continuous. A separate driving motor rotates the wheel assembly and welding is entirely continuous and automatic. The actual welding operation for one wheel is completed, on an average, in one hour. The rough surface is then refinished on a car wheel grinding machine.

CONTRACTS.—Messrs. Howden-Ljungström Preheaters (Land), Limited, of 133, Helen-street, Govan, Glasgow, have secured an order for a preheater from Messrs. S. Fielding and Co., Limited, of Devon Pottery, Stoke-on-Trent.—Messrs. Vickers, Limited, have secured an order for 100 single battery, electrically-regulated train lighting outfits for the new passenger carriages being built by the London, Midland and Scottish Railway Company.—The Leckhampton Quarries, Limited, have placed an order for a complete lime hydrating plant with Vickers and Internal Combustion Engineering, Limited.—Messrs. Stothert and Pitt, Limited, of Bath, have received an order from the Jersey Piers and Harbour Committee for several dockside cranes, and electric motors, together with electric lighting equipment, for St. Heliers, Jersey.—The Underground Railways of London have placed contracts with the Foundation Company, Limited, for the driving of escalator tunnels at the South Wimbledon and Collier's Wood stations on the extension of the City and South London Railway.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The state of the Scottish steel trade in general is still very unsatisfactory. New business is far from plentiful, and while some makers have been picking up a few more orders since the decontrol of prices, very keen competition has had to be faced. Shipbuilding material is moving very slowly, and there seems little probability of any expansion in this direction in the near future. The general demand is poor and inquiries are not very encouraging. In the black sheet trade the bookings are not much better, but a fair amount of work is still on hand. The outlet for galvanised sheets is good, and quite satisfactory shipments are going through. Prices in all departments are easier, and producers are willing to offer very keen quotations whenever a satisfactory price is asked for. The following may be taken as to-day's quotations for home delivery: Boiler plates, 12*l.* 10*s.* per ton; ship plates, 8*l.* 17*s.* 6*d.* per ton; sections, 8*l.* 7*s.* 6*d.* per ton; and sheets, $\frac{3}{8}$ to $\frac{1}{2}$ in., 10*l.* 5*s.* to 10*l.* 10*s.* per ton, all delivered Glasgow stations. The general export trade has shown a considerable falling off during recent months, and there are no indications of much, if any, change for the better in the current inquiry.

Malleable Iron Trade.—The West of Scotland malleable iron trade is still doing very poorly, and hand-to-mouth conditions are general. Easier prices have not brought out the business expected, although a few lines have lately been secured. The latter are just helping to keep plant in motion, and orders generally are quickly run off. Steel re-rolling branches are being kept going, but here, again, there is a lack of activity. Prices are without change, and "crown" bars are quoted at 11*l.* 12*s.* 6*d.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—No change of any description can be recorded in connection with the Scottish pig-iron trade this week. The demand in some quarters has been rather better, but the tonnage overall is not very heavy, and large stocks are general. Inquiries are only fair, and little expansion is likely meantime. Home consumers are buying with caution and hesitate to commit themselves on a falling market, while the export demand is very poor indeed. Prices are easier, and the following are the current market quotations: Hematite, 4*l.* 10*s.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 8*s.* 6*d.* per ton, and No. 3, 4*l.* 6*s.* per ton, both on trucks at maker's yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 9, amounted to 440 tons. Of that total 215 tons went overseas and 225 tons coastwise. For the corresponding week of last year the figures were 1,325 tons foreign and 148 tons coastwise, making a total shipment of 1,473 tons.

CALCIUM CARBIDE.—At one of the recent meetings of the British Acetylene and Welding Association in the Old Colony Club, London, when Mr. Charles J. Quirk presided, Mr. C. Coulson-Smith, M.Sc., Chief of the Laboratory Staff of Messrs. Allen-Liversidge, Limited, read a paper on "A Review of Calcium Carbide." In it he described the chemical changes taking place in the production of calcium carbide and the methods used in the process of manufacture. He then described means of detecting inferior carbide by its colour: the indifferent material has not the characteristic white appearance of the pure carbide. Good calcium carbide gave 4·8 cub. ft. of acetylene gas per pound but the red-tinted variety did not give so good a yield. Frequently erroneous views were entertained on the quality of calcium carbide because satisfactory crushing of the hard material was not obtained in the sampling process. Purifying methods to ensure the freedom of the gas from objectionable vapours and to obtain consistent work were then described by Mr. Coulson-Smith in concluding his review.

ASSOCIATION TECHNIQUE MARITIME ET AÉRONAUTIQUE.—The twenty-ninth annual meeting of the Association Technique Maritime et Aéronautique will take place on May 25, 26, and 27 at the offices of the Association, 7, Rue de Madrid, Paris (8), commencing at 9.15 a.m. each day. The papers to be read are the following: "Submarine Cruisers," by M. de Vito; "The Calculation of Fatigue Stresses in Submarine Hulls," by M. Lecoq; "An Investigation of Cost Systems in Mechanical Engineering Works," by M. Lorain; "Boiler Troubles: Characteristics of Burnt Tubes," by M. Do-Huu-Chan; "Note on Generated Gear-Teeth," by M. Delaporte; "Note on the Torsional Vibrations of Shafts," by M. de Saint-Aubin; "The Protection from Damp of Optical Instruments used on board Ship," by M. Perrin; "The Study of a Gyroscopic Anti-Rolling Apparatus," by M. Lavarde; "The Light Alloys and their Application to Naval Architecture," by M. Guillet; "The Elastic Limit, and the Modulus of Elasticity of Metals and Alloys," by M. Guillet; "The Design and Testing of an Apparatus for Decreasing the Rolling of Ships," by M. Bernier; "Rules and Regulations concerning Aeronautics of the Bureau Veritas," by M. Volmerange; "Note on a Parameter of Mechanical Similarity in Fluid Motions and its Application to Cavitation of Aerial Propellers," by M. Leroux; "Recent Progress in Increasing the Safety of Flying," by M. Sabatier; "Note on the Arrangement of Sails," by M. Létang; "The Protection of Merchant Ships from Accidents at Sea," by M. Marie; "Comparisons between Model Testing and Sea Performance," by M. Barrillon; "The Testing of a 500-h.p. Tug-Boat Propelled by a Screw in a Tunnel," by M. Guilloux.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Values of Cleveland pig-iron are easy, notwithstanding some little improvement in inquiries both on home and export account. A gratifying feature is the apparent feeling that quotations have touched bottom, which is emphasised by the fact that one or two forward contracts have been arranged at round about current rates. There is not a great deal of Cleveland pig available for prompt sale. No. 1 is put at 81*s.* The f.o.b. export quotation for No. 3 g.m.b. is 76*s.* 6*d.*, but for home consumption no difficulty is experienced in purchasing the ruling quality at 76*s.* Foundry 4 can be bought at 75*s.*, and No. 4 forge at 74*s.*

Hematite.—The home and overseas sales of one or two parcels of East Coast hematite have slightly strengthened the hands of producers of that commodity, but stocks are still heavy, and customers state they can secure price concessions on the recently reduced quotations. No. 1 is put at 81*s.* 6*d.*; and Nos. 1, 2 and 3 are 81*s.*

Foreign Ore.—Stagnation continues to characterise imported ore. Nominally sellers keep market rates on the basis of best rubio at 22*s.* c.i.f. Tees, but contracts might be arranged on lower terms.

Blastfurnace Coke.—Though production has been curtailed, Durham blastfurnace coke continues in ample supply, and good medium qualities can be bought at round about 22*s.* delivered to users here.

Manufactured Iron and Steel.—No new feature of moment is noticeable in the manufactured iron trade. Sales of semi-finished steel have shown some expansion, and there is a rather more hopeful feeling that export demand for finished steel may improve. A few home sales of constructional steel and of railway material have been made. Quotations are unsteady. The following may be given as among the principal market figures: Common iron bars, 11*l.* 12*s.* 6*d.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.*; steel billets (medium), 8*l.* 15*s.*; steel billets (hard), 9*l.* 10*s.*; steel ship, bridge and tank plates, 8*l.* 17*s.* 6*d.*; steel angles, 8*l.* 5*s.* to 8*l.* 10*s.*; steel joists, 8*l.* 5*s.* to 8*l.* 10*s.*; heavy sections of steel rails, 8*l.* 10*s.*; and galvanised corrugated sheets (24 in. gauge, in bundles), 16*l.* 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Another Shipping Crash.—Following the appointment of Sir Gilbert Garnsey as receiver and manager for Gould Steamships and Industrials, Limited, the Cardiff shipowning, shipbuilding and marine engineering firm, shareholders have received a circular convening an extraordinary general meeting for the purpose of passing a resolution to wind up the company as, "by reason of its liabilities, it cannot continue its business." The company was registered in 1920, with an authorised capital of 3,000,000*l.*, Mr. J. C. Gould being the governing director and Mr. W. T. Gould and the late Captain Lewis managing directors. The company owns eight steamers, totalling 63,176 tons deadweight; also the marine engineering works of Blair and Co., Limited, Stockton-on-Tees, and the shipbuilding concern of Richardson, Duck and Co., Limited. The directors, in their circular to shareholders, state that on several occasions they felt themselves justified in hoping that an improvement in conditions had set in, but on each occasion they have found themselves disappointed. The result is that with no contributions in the way of dividends from either Blair and Co., Limited, or Richardson, Duck and Co., Limited, and with great depression in the freight market, and the crushing burden of taxation, the company has found itself in difficulties as regards finding the moneys periodically necessary to carry out the arrangements under which the first mortgage debenture issue of the company was made. In the circumstances the directors have thought it their duty to invite the shareholders to wind up the company at once rather than to allow matters to drift.

Colliery Deal.—Negotiations have reached an advanced stage for the acquisition of the Windsor colliery owned by the Windsor Steam Coal Company (1901), Limited, by the Powell Duffryn Steam Coal Company, Limited, one of the largest colliery undertakings in South Wales. The collieries of the Windsor company are situated in the Aber Valley, where they embrace an area of about 2,600 acres, and have an approximate output of between 400,000 and 500,000 tons per annum, giving employment to over 2,000 workmen. The company has a share capital of 299,930*l.*, comprising 125,000*l.* in 6 per cent. preference shares, 74,930*l.* in 10 per cent. preference shares, and 100,000*l.* in 1*l.* ordinary shares. There are also 125,000*l* in 5 per cent. debentures. The 6 per cent. preference dividend is five years in arrear, and the 10 per cent. three years in arrear, while no dividend has been paid on the ordinary shares.

ROYAL SOCIETY OF ARTS.—Under the Fothergill Trust, the Council of the Royal Society of Arts offer a prize of 100*l.* for an essay on "Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain." Intending competitors must send in their compositions not later than July 31, 1926, to the Secretary of the Society, John-street, Adelphi, London, W.C.2, who will give all particulars.

NOTICES OF MEETINGS.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—To-night, at 9 p.m., at Albemarle-street, W. 1. "Recent Developments in Magnetism," by Professor C. G. Darwin. Tuesday, May 19, at 5.15 p.m. "Passage of Electricity through Vacuum Tubes" (Lecture I), by Professor R. Whiddington.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: YORKSHIRE DISTRICT.—Saturday, May 16, at 10 a.m., at the Town Hall, Wath-upon-Dearne. "Municipal Works and Undertakings, Wath-upon-Dearne," by Mr. Harry Cranage. Various visits.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: SOUTH-WESTERN DISTRICT.—Saturday, May 16, at 11 a.m., at the Town Hall, Tiverton. "Nearly Forty Years' Municipal Work in a Small Borough," by Mr. J. Siddalls. Discussion on "Housing under Recent Legislation." Various visits.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Monday, May 18, at 7 p.m., at Storey's-gate, S.W. 1. Graduates' Section. Annual Meeting. "Some Factors in the Choice of the Best System of Traction for Handling Dense Suburban Rail Traffic," by Mr. P. W. Thomas, B.Sc. Friday, May 22, at 6 p.m. Extra General Meeting. "Some Tests on a Two-Stroke Cycle Oil Engine," by Professor E. A. Allcut, M.Sc.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, May 19, at 7 p.m., at the Lighting Service Bureau, 15, Savoy-street, Strand, W.C.2. "A Survey of Lighting in 800 Retail Shops," by Mr. W. J. Jones and Mr. H. Lingard.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, May 20, at 5 p.m., at 49, Cromwell-road, South Kensington, S.W. 7. "Further Remarks on the Meteorological Conditions of the Pleistocene Epoch," by the late Mr. F. W. Harmer, F.G.S., and Mr. C. E. P. Brooks, M.Sc. "On Periodicity," by Sir Gilbert T. Walker, F.R.S. "On Fluid Motions produced by Differences of Temperature and Humidity," by Mr. Harold Jeffreys, M.A., D.Sc. "Gustiness of Wind in Particular Cases," by Mr. A. H. R. Goldie, M.A.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Wednesday, May 20, at 7.30 p.m., at the Engineers' Club, Coventry-street, W.1. "Mechanical Costing," by Mr. S. C. Downes.

THE ROYAL SOCIETY OF ARTS.—Wednesday, May 20, at 8 p.m., at John-street, Adelphi, W.C. 2. Ordinary Meeting. "William Sturgeon, and the Centenary of the Electromagnet," by Professor John Ambrose Fleming, M.A., D.Sc., F.R.S. Friday, May 22, at 4.30 p.m. Indian Section. "The Industrial Progress of the Mysore State," by Sir Alfred Chatterton, C.I.E., B.Sc.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, May 21, at 5.30 p.m., at the Geological Society, Burlington House, Piccadilly, W.1. "Underground Orientation by Exact and Approximate 'Alignments' of Plumb-wires in one Shaft," by Mr. L. H. Cooke. "Mines and Mineral Deposits of Canada," by Mr. R. P. D. Graham.

THE DIESEL ENGINE USERS' ASSOCIATION.—Friday, May 22, at the Engineers' Club, Coventry-street, W.1. "Pyrometry of Exhaust Temperatures of Internal Combustion Engines," by Mr. Chas. E. Foster.

THE NATIONAL PHYSICAL LABORATORY.—A pamphlet has been issued, dated May, 1925, by the Metrology Department of the National Physical Laboratory, Teddington, giving full information regarding the conditions under which the verification of weights, the testing of balances, and the determination of densities of substances are undertaken by the Department. Particulars of the nature of the tests applied, and the costs involved, are also given in this leaflet, copies of which may be obtained free from the Director of the National Physical Laboratory.

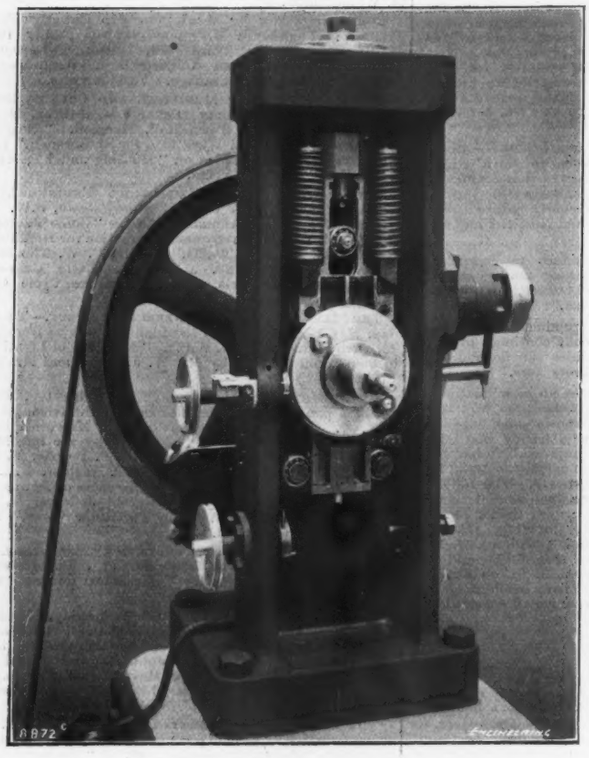
THE LATE MR. A. E. WELLS.—The death of Mr. Alfred E. Wells occurred on May 11 at Southlands, Moorgate, Rotherham. The deceased, who was 67 years of age, was a well-known steel manufacturer in the Sheffield district, being managing director of Messrs. Edgar Allen and Co., Limited, of Imperial Steel Works, Tinsley. He was a son of the late Mr. George Wells, of Messrs. J. and G. Wells, colliery owners, and was born at Eckington, Derbyshire. Educated at the Academy, Bradford, he commenced his connection with the steel industry about half-a-century ago, and in 1890 became associated with Mr. William Edgar Allen at Tinsley. During the war Mr. A. E. Wells was chairman of the Board of Management of one of the National Shell Factories.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The Council of the Institution of Electrical Engineers has awarded a number of premiums to contributors of papers submitted during the session 1924–25. Of these awards the Institution Premium has been secured by Mr. H. W. Clothier, the Ayrton Premium by Major E. I. David, the Fahie Premium by Colonel T. F. Purves, and the John Hopkinson Premium by Mr. G. Rogers. Lieut.-Colonel K. G. Maxwell and Mr. A. Monkhouse have gained Kelvin Premiums, while the Paris Premium has gone to Mr. D. Murray. Professor Miles Walker and Messrs. J. D. Cockcroft, R. T. Coe, J. A. Tyacke and H. S. Holmes have been awarded Extra Premiums, while Professor E. Mallet, Major A. G. Lee, Captain H. J. Round, and Messrs. A. J. Gill, T. L. Eckersley, K. Tremellen, F. C. Lunnon, A. D. Blumlein and L. C. Pocock have received Wireless Premiums.

UNIVERSAL ENDURANCE IMPACT TESTING MACHINE.

CONSTRUCTED BY MESSRS. ALFRED J. AMSLER AND CO., ENGINEERS, SCHAFFHAUSEN, SWITZERLAND.

(*For Description, see Page* 604.)



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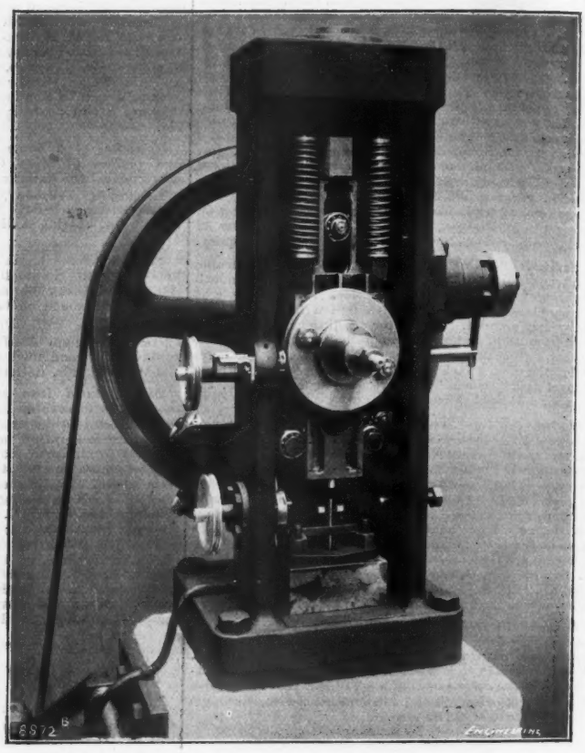

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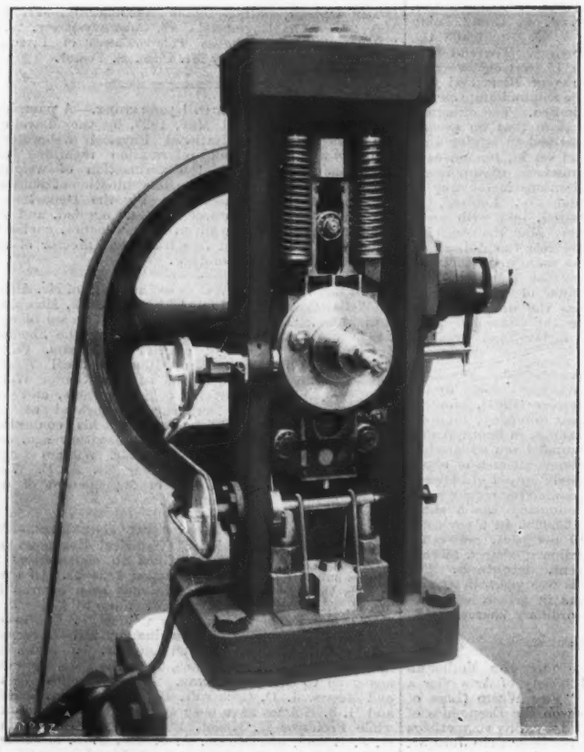

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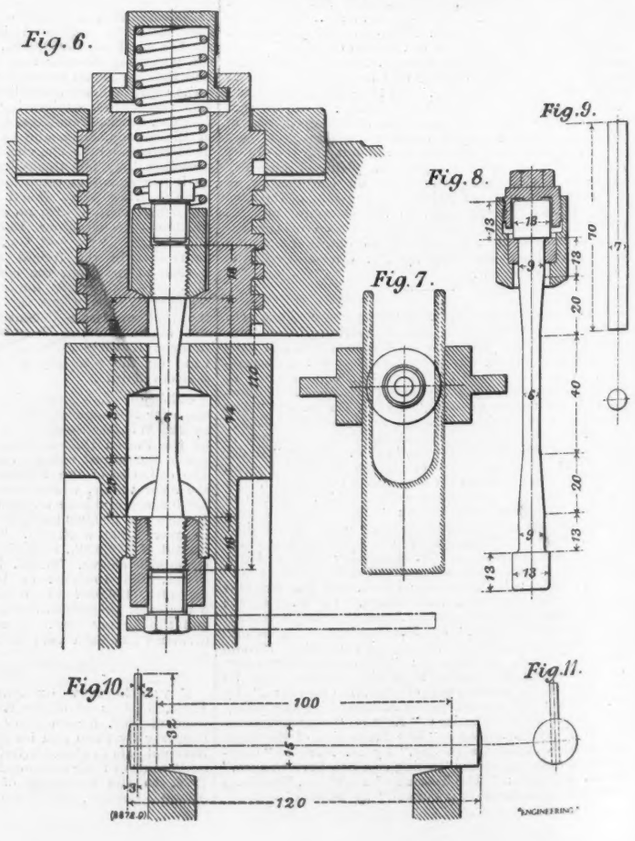

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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One Two-Page Plate and Two One-Page Plates.—*PUMPING STATION FOR THE LITTLETON RESERVOIR.*

ENGINEERING.

FRIDAY, MAY 15, 1925.

LORRIES FOR HEAVY TRANSPORT.

In the early days of road transport development the rival merits of steam and internal-combustion engines for motor vehicles was a subject of bitter controversy, but as a result of extended experience it became generally accepted that the two types were to a large extent complementary. With a few unimportant exceptions, the internal-combustion engine has now been recognised for a number of years to be particularly suitable for pleasure vehicles and light goods service; while the steam engine has enjoyed an almost unchallenged field in the heavier class of goods service. There has thus been little competition between the two types except in border-line cases lying between 3 and 4 tons, or where the conditions were sufficiently unusual for the characteristics peculiar to one type of vehicle to weigh against the normal superior economy of the other. Quite recently it has become apparent that petrol-engined vehicles are being used for loads above those which had previously been regarded as the economic limit for this type of vehicle. It is pertinent to inquire whether history is about to repeat itself, and the steam vehicle is being driven from the field in the heavier class, as it had previously been driven from the lighter class of service, by its competitor.

It is necessary to recognise at the outset that the steam-driven vehicle has certain fundamental disadvantages as compared with its rival, and that it can only hope to hold its own in fields where it can show marked superiority in economy. Amongst other points, time is lost in getting the steamer on the road, it is more dangerous to take under cover on account of fire risks, and it is essentially dirty. When comparing the economy of the two types, consideration has to be given to running, standing, and establishment charges. In the case of the steam vehicle the lower fuel cost has been to a great extent offset by the low efficiency and high maintenance charges associated with the boiler, and it is probable that the future of the steamer will depend on the success or otherwise of the endeavours made to improve this unit. Apart from the question of their relatively heavy weight and high cost, the various types of boiler utilised in the past for steam vehicles have achieved a somewhat unenviable reputation in respect of such points as burning out, leakage, and amount of attention required. In a paper read by Mr. Clarkson before the Institution of Engineering Inspection recently it was suggested that the design of small capacity boilers had not received the attention which its importance merits.

The paper was entitled "The Evolution of Steam Boilers for Special Purposes," and the position held by Mr. Clarkson in the industry lends great interest to his comments. He confined his attention to boilers having an evaporative capacity of less than 3,000 lb. per hour; in other words, to boilers of the type fitted to road vehicles, and used to a comparatively small extent for other classes of work. The conditions of service to which boilers of this class are subject are very severe as compared with large capacity land or marine boilers; and the summary of the desirable qualities for such a boiler given in the paper sufficiently emphasizes this point. Thus Mr. Clarkson stated that it was desirable that the boiler should be fool-proof as far as possible, should be unaffected by bad water, and should be completely immune from leakage and scaling. It must be capable of enduring long periods of service without overhaul and without appreciable loss of efficiency, and it should not be affected by forcing. These qualities are all required in a small boiler producing steam at a pressure of from 230 lb. per square inch to 250 lb. per square inch at a temperature of from 650 deg. F. to 700 deg. F., utilising a cheap fuel such as coke. Even this does not exhaust the list of requirements, as it should also be possible to raise steam quickly from cold, and to maintain a full head of steam under adverse conditions.

The flash boiler offers a ready solution to several of the important requirements in Mr. Clarkson's list, but, unfortunately, its good qualities for this class of work are offset by its weakness in other directions. It is still preferred by some makers for the lighter class of vehicle, but for heavy service boilers of more normal type are used, which, although heavier, meet the requirements better as a whole. With the exception of detail modifications, the majority of the most successful boilers in use on road vehicles follow larger practice fairly closely, both vertical and horizontal types being represented. The most striking exception is, perhaps, the thimble tube boiler designed by Mr. Clarkson, which has given remarkable results in actual use. We described this boiler in our issue of August 19, 1921, and it has only been modified in detail since that date. It will be recalled that it is of the vertical type, consisting essentially of two concentric shells with the water and steam space between them, a number of thimbles projecting inwards from the inner shell into the gases, which pass up the centre.

Some extremely interesting results obtained on a fleet of vehicles owned by Messrs. H. Viney and Co., Limited, of Preston, Manchester, and Liverpool, utilising this boiler, have recently been published in *The Times*. Messrs. Viney have had a very wide experience in the operation of transport services, and their fleet now consists of 26 steam wagons and six 6-ton petrol lorries, nearly all of Leyland manufacture, which work with trailers and haul maximum loads of 10 tons. The majority of the steamers were originally fitted with Leyland water-tube boilers, but these have been almost entirely replaced by Clarkson boilers. These vehicles run on an average 12,000 miles per year, and their total individual mileage is now between 120,000 and 140,000. It is stated that after a life of about 10 years, the machines can be kept working on the roads for periods of two years between general overhauls, the boilers merely being washed out every week in the intervals. The company states that after four years' continuous use, the thimbles show no sign of corrosion or deterioration, and that in consequence it is difficult to give a period for their length of life. All the steam wagons use coke fuel, which is started by gas burners, and this, besides resulting in a very appreciable economy in

firewood, &c., has the effect of drying the coke, resulting in a reduction in the emission of smoke and acid fumes from the chimneys.

The article from which we have quoted compares the relative costs of running a steam wagon and trailer with those of a petrol lorry and trailer, but in this comparison the age of the steam wagons should be taken into account, and also the present high cost of gas coke. Space does not permit of our quoting the figures in full, but for the steam wagon and trailer the total figures are 8·78*d.* per mile for running costs, 9·61*d.* for standing charges, and 6·53*d.* for establishment charges. In the case of the petrol lorry and trailer the corresponding figures are 8·28*d.*, 7·78*d.*, and 5·20*d.*, respectively. It will be observed that in each case the petrol vehicle shows to advantage, but this can in part be accounted for by the fact that the mileage per week was 330, as against 270 for the steamers. The reason for the difference in mileage is not stated, but is presumably due to the higher average speed of the petrol vehicles. The cost of the coke used on the steam wagons is given at 2·88*d.* per mile at 30*s.* per ton. The pre-war cost of coke was about 9*s.* per ton, and at the latter rate the cost per mile would work out at 0·864*d.* This would reduce the running cost of the steamer to 6·764*d.* per mile, as against 8·28*d.* for the petrol vehicle, but the latter would still have the advantage as a whole on the figures given, due to the lower standing and establishment charges. The difference in the standing charges is almost entirely due to the difference in mileage, as is the difference in establishment charges with the exception of the items for damage and drivers' expenses, which are both higher in the case of the steam wagon. The crux of the question, however, is the mileage covered by the two types, and if the assumption is correct that this is due to the higher average speed of the petrol lorries, it would appear that full advantage cannot be taken of the possibilities in the direction of superior fuel economy in the case of the steam wagons unless their mileage can be brought up to that of the competing machines.

It would thus appear that there is some evidence available to show that the internal-combustion engine offers a superior economy in the field which has generally been regarded as belonging exclusively to the steam engine, at the ruling fuel prices, and it would be interesting to know what characteristic is possessed by the latter which accounts for its continued extensive use, particularly in the north of England.

ACCIDENTS WITH EXPLOSIVES.

A LESSON may be drawn from the number of accidents in the manufacture, storage, transport and use of explosives, of the value of the control by His Majesty's Inspectors of Explosives, under the provisions of the Explosives Acts of 1875 and 1923. In the Annual Report recently prepared for the year 1924, which has now been published by H.M. Stationery Office, Adastral House, Kingsway, London, at a price of 1*s.* net, the information relating to the accident experience each year is presented in a form which may be easily appreciated. In 1924 there were 426 accidents caused in the course of manufacture, storage, transport or use of explosives, and these resulted in 59 deaths and the injury of 404 other persons. Only the official classification "use and miscellaneous" covers circumstances to which the controlling provisions of the Explosives Acts do not apply, and it is informative on the value of the regulations that less than 6 per cent. of the accidents were found in the work involved in the proceedings controlled by regulations during the year. Of the total casualties, three deaths and 28 injuries were caused in these classes of work.

In the United States of America there are no Federal or State regulations, but voluntary agreements made by the manufacturers, who have combined to form the Institute of Makers of Explosives, take their place. At the meetings of this Institute details of accidents are presented and discussed, and the means necessary to prevent a recurrence of the same trouble are decided upon. These are then put into force by the various firms. In the event of a serious accident, the Institute appoints a commission to conduct an enquiry and report upon the occurrence. In addition to this activity, the Institute frames regulations for such matters as the packing of explosives and the marking of the packages for conveyance by road. The most striking difference between American and British explosive manufacturing methods is that gunpowder mills are worked with much larger charges in the U.S.A. and Canada than would be permitted in this country. Much of the disparity in the quantities that can be treated at one time may, however, be removed by increasing the distances from other danger buildings in the works of the British producers, and licences may be then obtained to deal with the greater charges. When suspended runners are used, which is the common practice in the U.S.A., charges up to 150 lb. may be dealt with without any alteration in existing conditions in British works.

Owing to the low temperature conditions met with, and the consequent difficulties of having to deal with frozen nitro-glycerine in cartridges, nearly all the nitro-glycerine manufactured in the North American continent, termed "low-freeze," is, practically speaking, unfreezable. Difficulties from frozen nitro-glycerine are therefore eliminated during manufacture, transport and use, and many accidents are prevented. H.M. Inspectors of Explosives are at present in consultation with the Mines Department and with the various manufacturers with a view to finding to what extent "low-freeze" nitro-glycerine could be introduced into this country. This type of explosive has, of course, the disadvantage of greater insensitiveness to detonation, and the troubles that this might cause have to be carefully considered.

In regard to the use of substances coming within the provisions of the Petroleum Act of 1871, some troubles were experienced during the year 1924 which throw light upon dangers which have previously not been realised. For instance, although it is a common belief that a red cigarette end will not ignite petrol, a very bad accident caused by ignition in this way resulted in the injury of two people. Another occurrence worthy of comment was the explosion of petrol vapour and air caused by the generation of static electricity by the friction of the spirit passing into two tank wagons. Experiments have shown that static electricity is generated in pipe lines when petroleum is passed through them and, if the vessels into which the petrol or paraffin is passed are insulated, charges capable of giving measurable sparks may be collected. In view of this, a new series of measures have been taken to prevent the recurrence of similar accidents. Comment is also made in the Report on the changed construction, which has been adopted by the manufacturers, for cylinders containing dissolved acetylene, because of an accident caused by the weakness of the ends of the old cylinders, which was demonstrated through the dropping of a cylinder at Greenock in October last when 36 people suffered injury.

THE INSTITUTE OF TRANSPORT CONGRESS.

A LONDON Congress of the Institute of Transport was opened on Wednesday last, May 13, and terminates on Saturday, May 16. The programme includes the reading of, and discussion on, some five papers, and a number of visits to places of interest. The Congress was formally opened at 9.45 a.m. on Wednesday, when the President of the Institute, Sir Lynden Macassey, welcomed delegates and visitors, at the Institution of Electrical Engineers, where the Congress is being held.

The first two papers down for reading were "The Ministry of Transport Requirements for 1925," by Colonel Sir John Pringle, C.B., and "Airships and Their Uses both as Commercial Vessels and in Time of War," by Commander C. D. Burney, C.M.G. In the unavoidable absence of Colonel Pringle the former paper was read by Major G. L. Hall, R.E. The chair at the meeting was taken by Mr. R. T. Smith, who after the paper had been read proposed a vote of thanks to the author and to Major Hall. He mentioned that the paper to a large extent constituted a historical review of the various reports issued first by the Board of Trade and later by the Ministry of Transport, and concluded by emphasising the statement made by Colonel Pringle in his paper, that it is most necessary to keep an open mind upon all new methods of railway operation. The vote of thanks was seconded by Mr. A. Cooper.

MINISTRY OF TRANSPORT REQUIREMENTS, 1925.

The following is a summary of Colonel Pringle's paper:—The first memorandum issued under Government auspices dealing with transport requirements was issued in 1858, and since that date other reports have been issued at short intervals embodying the experiences gained in actual working. After the memorandum issued in 1914, the war resulted in the postponement of further revision of the regulations, but in 1920 a new revise was taken in hand, and finally published in the present year under the title of "Requirements for Passenger Lines and Recommendations for Goods Lines of the Ministry of Transport in regard to Railway Construction and Operation." In this revision the co-operation of railway technical officers was obtained for the first time, the Clearing House nominating eight officers to assist the inspection officers in drawing up the report. The latter embodies the result of experiments undertaken to ascertain the necessary clearance between passing vehicles, and also of the work of the British Engineering Standards Association on girder bridges. Owing to the unavoidable delay in publishing the report, the most recent developments in colour light and four-aspect signalling and electrification are not included.

The report differs from its predecessors in setting forth desiderata for safety and convenience in respect of first construction, reconstruction or alteration, and of operation of all types of lines. It emphasises the desirability for economy and simplicity in signalling with due regard to safety, and indicates that standardisation on board principles is necessary in this connection. It deals for the first time with the preservation of minimum acceptable clearances between passing trains and between trains and structures. Appendices deal with fire precautions on electric railways, regulations regarding the use of continuous brakes, and cognate matters. In the report automatic signalling is recognised as an approved alternative to the block telegraph, and for the first time colour-light signals are specified as acceptable. A third colour, yellow, for caution is introduced, and the National Physical Laboratory has established higher and lower standards of tolerance for all three colours. Red and yellow, instead of red and white, are named as the alternative normal indications for the front lights of two-position shunt signals. The track-circuited diagram is given as an approved alternative to visual location from the signal-box, and the limit of distance for levers working both trailing and facing points is extended to 350 yards. In the case of power-operated points with electrical indication this distance may be extended indefinitely. Electrical interlocking is referred to as necessary between block or token instruments and the levers operating points and signals. The use of a track circuit is required to be accompanied by visual indication in the signal-box of the occupation of the track.

For the first time, the report sets forth that ambulances, first-aid requisites, salvage tools and fire extinguishers are desirable on all passenger trains, whether steam or electrically operated. It also specifies that all new and reconstructed stock should be electrically lighted. In dealing with clearances, Colonel Pringle mentions that since 1858 the width of carriage stock has been increased by 2 ft., while the 6-foot space and lines of structure have remained unaltered, so that clearance between passing trains has gradually diminished from 3 ft. 6 in. to 1 ft. 6 in. The question of clearance has, therefore, demanded very careful attention, and, as a result of the experiments referred to 1 ft. 6 in. was fixed as a minimum between passing trains. No increase in the 6-foot way is contemplated, and the old clearance of 2 ft. 4 in. between

the side of the widest stock and any standing work is retained. It is considered that the desirable lateral width for a double line is 26 ft. 6 in., and the desirable vertical standard clearance above rail level 15 ft.

In opening the discussion Major C. H. Edmunds mentioned that the paper showed that a considerable period usually elapsed between the first application of any new proposal and its incorporation in the official requirements. The average period appeared to be about 15 years, but it was probable that in the future this could be considerably reduced, and it would appear that this was very desirable in the case of such important questions as automatic train control and continuous brakes for goods trains, which were both referred to in the paper as subjects of great future importance. The paper gave ample evidence that the authorities approached the framing of regulations with a very open mind, and the comments on double-wire point operation offered a case in point. It was important to observe in this connection that the practice in point operation adopted in England made for safety regardless of the method of operation, as it was based on the detection of the movement of the points. With regard to the acceptance of colour light signals, he did not regard the use of a green light in both position and shunt signals as satisfactory, and suggested that a white light might be employed instead in the case of a position signal.

Mr. W. Murray raised the point that the title of the paper appeared somewhat misleading, as he was personally under the impression that it covered road as well as railway practice. He suggested that it would be desirable in a future conference to embody papers covering such important questions as traffic congestion on roads and the licencing of motor vehicles by local authorities.

Mr. W. J. Thoroughgood commented on the magnitude of the task carried out by the Ministry and the liberal manner in which the report had been framed so as to leave it open for the incorporation of further improvements. The portion of the paper dealing with signalling was especially valuable as tending to produce uniformity in practice and so lead to simplification of existing systems. In dealing with colour signalling, he regarded it as of great importance that yellow should be confined to precautionary signals, and felt that the present practice of defining yellow as lying between two specified limits was unsatisfactory. He thought that the provision of a standard single yellow tint was urgently required.

Mr. A. G. Wilding mentioned that yellow was at present used both for running lights and for stop or precautionary lights. He considered that in dense areas yellow lights were somewhat dangerous, as they might be taken by the driver to indicate that a section was clear. He also thought that confusion might occur in fog between a yellow ground signal and a fogman's signal. In reference to quadrant signalling, he thought that the use of the upper quadrant represented the safest practice as in the event of a failure in the control the signal would always drop to danger.

Mr. Lowe-Brown referred to the regulation regarding the continuity of the footboards throughout a train, and mentioned that this had been found undesirable in India as it facilitated train robberies.

Mr. Sherry mentioned the extent to which automatic train control was used in the United States, 46 divisions having been fitted with this system some time ago, and 20 or 30 more having been added recently. He stated, however, that, although some five to seven systems were in use, none of them was found to be completely satisfactory, and it would appear from this that it might be desirable to wait for further experience to be gained before deciding on any one system.

In replying to the discussion, Major Hall referred to the value of the co-operation which had taken place between the Government and railway officials. In reference to Major Edmunds' remarks, he thought that the period of incubation referred to was of considerable value, as it was undesirable to make regulations until full opportunity had been accorded for trying out any new idea. He thought that the dangers which had been referred to in connection with colour signalling could easily be overemphasised, as a driver would always be perfectly familiar with the difference between running and shunt signals. In reply to Mr. Thoroughgood, he mentioned that in the case of both shunt and running signals yellow indicated caution. He did not think that there could ever be any confusion between ground and fogman's signals, as the latter would only have a two-aspect hand lamp. As regards Mr. Wilding's second point, he did not think that the upper quadrant was any safer than the lower in quadrant signalling, as a counterweight was always provided to throw the signal to danger in the event of breakage in the latter case.

Airships and Their Uses.

Commander Burney's paper on "Airships and Their Uses, both as Commercial Vessels and in Time of War," opened by dealing with experience gained during the war, which showed that the role of this type of ship was essentially that of a long-range scouting vessel for use with the Navy. Owing to the entire re-orientation of world naval power since the war, the Pacific is now the centre of gravity of the world's naval forces, and to reconnoitre and patrol these vast areas by means of cruisers would involve an expenditure beyond the Empire's capacity. The number of airships available in time of war is thus a question of the first importance, and in this connection it must not be forgotten that during the last war for every one vessel belonging to the Royal Navy, at least four vessels were drawn from the mercantile marine and pressed into service. From this the lesson may be drawn that if airships are to be of use in war, an equivalent class for commercial use in peace-time must be in existence in considerable numbers. In addition, before the airship can be accepted as a satisfactory alternative to the cruiser, it is necessary to prove that its reliability in service is of an order comparable with that of the latter.

Turning to the capabilities of the vessels that are being constructed to-day, the 5,000,000 cubic foot vessel now being built by the Airship Guarantee Company for the British Government will have a useful lifting capacity of about 75 tons and, flying at 5,000 ft., will have a speed of about 90 m.p.h. Allowing for the weight of fuel, the vessel should maintain an average speed of 70 m.p.h. for a distance of 3,500 miles without re-fuelling, while carrying 140 passengers and 7 tons of mails. For reconnaissance purposes a distance of approximately 10,000 miles could be achieved at the same speed without re-fuelling. The change over from commercial to reconnaissance use can be made without material alterations, and the commercial development of airships would thus automatically secure our war reserve of cruisers.

The question of whether commercial airships can be made to pay thus becomes of the first importance, and from experience gained in other forms of transport it appears to be unsound to base expectations in this direction on the assumption of higher fares than those obtainable on the ocean steamship lines. The same consideration holds to a great extent in the case of mail fees, and it follows that the requisite financial return can only be expected if large numbers of passengers and large quantities of mail are available for this means of transport. In addition, it would appear fundamental that the frequency of service should not be less than the total time of transport. Applying these considerations to the case of a service to South Africa, the total number of first-class passengers carried from England last year was just over 8,000, and if half these were to be carried by airship it will be observed that the amount of traffic available is relatively small. The routes most likely to be established within a reasonable period is England to New Zealand, and on the assumption that 50 per cent. of the capacity of the airship was taken up on the average the following charges upon this route have been adopted for purposes of estimating. England to Bagdad, 50*l.*; England to Colombo, 100*l.*; England to Perth, Australia, 140*l.*; England to Wellington, New Zealand, 170*l.*; taking a surcharge of 4*d.* per letter over the existing 1½*d.* for all letters irrespective of their destinations, it is estimated on these figures that the total revenue on this route would be 1,775,000*l.* The total costs are estimated at 1,686,000*l.*, leaving a gross profit of only 89,000*l.* Conservative figures have been taken for working costs, 240,000*l.* being assumed for material and labour for repairs, and the whole fleet is assumed to be written off every three years.

As it is uncertain to what extent the public will patronise the service, some form of subsidy during the initial stages is essential. It is possible that the gross loss upon the first year's working might amount to 1,000,000*l.*, and it is the question of providing a subsidy of perhaps at least 500,000*l.* per annum which constitutes the main difficulty. It should be realised, however, that where very high speed is required subsidies are always paid, as in the case of mail subsidies to steamships. A commercial programme on subsidised lines was approved by the Government in 1923, the scheme being a long period arrangement lasting over fifteen years, thus allowing a considered policy of airship development being followed. It was expected that by the end of the period the ships would be running on a self-supporting basis.

(To be continued.)

CODES FOR RECORDING HEAVY-OIL ENGINE TRIALS.

The desirability of formulating codes which will meet with general acceptance for recording the results of various engine trials has long been recognised, and this has formed one of the definite objectives of the Heat Engine Trials Committee appointed by the Institution of Civil Engineers, some years ago. A special committee was appointed in due course by the main committee to deal specifically with the tabulation of the results of heat engine trials, and a meeting was held in the Institution building on Wednesday, May 6, for the purpose of discussing the standard code drawn up by the latter body to cover a heavy oil engine trial. The special committee has had the advantage of co-operation with practically every body of engineers who are directly or indirectly interested, and as a result the list of bodies who were invited to take part in the joint meeting is exceedingly comprehensive. In addition to eight of the larger Institutions, it includes the British Electrical and Allied Manufacturers' Association, the British Engineers' Association, the Admiralty, the War Office, and the Air Ministry.

In introducing the subject of the code on behalf of the committee, Mr. James Carnaghan mentioned that the standard form presented to the meeting for consideration was intended to indicate all the necessary information for a comprehensive trial, but that it was also drawn up with a view to its use in connection with trials for industrial purposes. In order to render the form suitable for both purposes, the items which applied particularly in the case of industrial trials had been marked with an asterisk. The combination of the codes in this way was merely intended to be a temporary measure to facilitate discussion, and the committee announce that their provisional intention is to embody two separate classes of code in their report on heat engine trials, one for a comprehensive trial, and the other for a trial for industrial purposes. In the code which formed the subject of discussion at the meeting, the determination of calorific values, temperatures and pressures; the methods of measurement and the use of instruments; the definitions and values of fundamental data; and governor tests are all excluded, and it is proposed to deal with these separately at a later date.

In tabulating the report, the general information and design data are drafted in such a manner that constituent parts not included in the installation to be tested can be deleted. It is not practicable to arrange the code to cover extreme cases of divergence from standard or generally accepted design, but the committee have endeavoured to make it sufficiently wide to cover all normal divergences in design. The contents of the code are tabulated in five parts under the respective headings of general information, design data and detailed description of engine; methods of measurement; mean observations derived from log sheets and preliminary

deductions; final deductions; and heat account. The code is accompanied by a comprehensive series of notes for the purposes of instruction and elucidation.

The discussion which took place at the meeting mainly centred on the form of code desirable for industrial tests. It was suggested by several of the speakers that the items on the report marked with an asterisk formed an unnecessarily comprehensive list for many forms of test, and if adhered to would render an ordinary commercial test prohibitive in cost. In this connection, it appears desirable to define the type of engine to which the code is intended to apply. If any engine using a fuel covered by the specifications drawn up by the British Engineering Standards Association for heavy oils is regarded as a heavy oil engine for purposes of definition, the power may vary between 5 and 500 or over. Small engines which are turned out to standard designs in large numbers are thus included, and it is obvious that the industrial code was never intended to apply to engines of this type. The task of drawing a hard-and-fast line of demarcation appears to us to be impossible, and it is probable that the limit of application of the code can well be left to the manufacturer. The degree of standardisation achieved rather than the actual size would appear to be the crucial test, in that it might be desirable to use the code in the case of quite a small engine of new type, but it would become unnecessary to apply it to every engine of the same type turned out after the design became standardised.

There appeared to be a general feeling amongst those present at the meeting that a simplified code would meet all the necessary requirements in the case of many industrial tests, and Sir Ernest Petter suggested that the results of trials might be divided into three classes based on the power of the engine, and that each class might have its appropriate code. The consensus of opinion appeared to be, however, that the two forms of code suggested by the committee should be retained without reference to engine power, and that a third code should be introduced to cover single cases on the lines of the usual acceptance test. Sir Ernest also raised an important point with regard to engine rating. He pointed out that manufacturers' ratings varied as between this country and Continental and American firms, and suggested that it was desirable that the exact meaning of the term "manufacturers' rating" should be clearly defined. We believe that Sir Ernest's view that the definition, established by the British Engineering Standards Association in their specification for heavy oil engines for electrical purposes, should be accepted in all cases, will meet with general approval.

The question as to whether the calorific value of the fuel should be specified as the gross or the net value was discussed at some length. Captain H. Riall Sankey mentioned that this point had received the careful attention of the committee, and that bearing in mind the decision reached by the Boiler Trials Committee, they had desired to adopt the gross value. The main argument in favour of the gross value is that it can be definitely determined by means of an ordinary calorimeter without troubling about the water of condensation, whereas the net value depends upon a correct determination of the latter, and upon chemical estimations which are outside the usual range of engineering practice. In speaking in favour of the use of the gross value, Mr. R. H. Parsons pointed out that the use of this value was more logical, as it represented the actual calorific value of the fuel, and although the difference in the two values could not be utilised by the ordinary engine, it was more reasonable to regard this as a failing of the latter rather than as a fundamental fact. More than one speaker expressed the opinion that it was desirable to insert both values in the code, and it was finally agreed that a suggestion to this effect should be made to the committee, with a recommendation that the gross should be regarded as the standard value. A proposal was made by Mr. W. A. Tookey that a note should be appended on this point giving the percentage difference between the two values for computation purposes, and the speaker suggested that this might be taken as 10 per cent. in the case of gas and 7½ per cent. in the case of oil. Mr. Parsons objected that 10 per cent. could not be regarded as even an approximate figure in the case of gases containing a large percentage of methane, and it was agreed that it would be necessary to modify the figure in this case.

The remainder of the discussion was largely devoted to minutiae dealing with the notes accompanying the code. The suggestion made by Mr. B. Pochobradsky that trial reports should be accompanied by a graphical representation of the more important results is certainly worthy of consideration. Several of the points raised were in connection with methods of measurement and the use of instruments, and will no doubt receive further consideration when this portion of the work of the committee is presented for further discussion. Perhaps the most important point raised in this connection was the suggestion put forward by Mr. C. W. J. Taffs that fuel samples should always be determined by allowing a tapping to drip from the actual pipe delivering fuel to the engine during the time of the test. Discrepancies arising from the tendency of some of the heavy fuels to stratify in the tank would thus be avoided.

THE LATE MAJOR WILLIAM H. WILEY.

IT is with particular regret that we have to record the death of Major William Halsted Wiley, which occurred on the 2nd inst., from heart failure, following on pneumonia, at his home in East Orange, New Jersey, U.S.A. Major Wiley was, perhaps, best known in this country as the head of Messrs. John Wiley and Sons, of New York, a firm having a world-wide reputation as publishers of technical and scientific books, many of which are held in high esteem by British engineers. As the New York correspondent of ENGINEERING, moreover, he was the means of bringing many important American engineering undertakings to the notice of the technical public in this country, his lucid descriptions supplying just that information which is appreciated by engineers.

Although born in New York City, on July 10, 1842, Major Wiley spent his early life at East Orange, but graduated from the College of the City of New York, in 1861. His studies, however, were interrupted by the outbreak of the Civil War, in which he first served as second lieutenant in the Independent Corps of the New York Volunteer Light Infantry. Afterwards, he rose to the command of two companies of light artillery, and retired as a brevet major in 1864, having received special mention for his services during the siege and bombardment of Fort Sumpter and Charleston. Resuming his studies after the termination of the war, Major Wiley obtained a degree in engineering at the Rensselaer Polytechnic Institute, at Troy, afterwards passing through a special course of study at the Columbia School of Mines. His real life's work, however, may be said to have commenced in 1876, when he joined Messrs. John Wiley and Sons, the publishing house founded as far back as 1807, by his grandfather, Charles Wiley. This firm, which conducted a general publishing business for many years, has devoted its attention exclusively to the production of scientific and technical books for some forty years, having, at the present time, nearly 1,000 works of this character on its lists. It was incorporated in 1904, when both Major Wiley and his elder brother, Charles, became officers of the Corporation, the former becoming president and the latter acting as vice-president until the time of his death in 1916.

The subject of our memoir was a member of Congress, representing a district of New Jersey from 1903 to 1907 and from 1909 to 1911, and also belonged to numerous scientific and other societies. Of these we may mention, in particular, the American Society of Mechanical Engineers, of which Major Wiley was treasurer for many years, also acting as chairman of the National Preparedness Committee of that Society during the Great War.

He did other valuable public work as New Jersey Commissioner to the St. Louis Exhibition, held in 1904, and as President of the International Jury of the Brussels Exhibition of 1907. In the course of his career, Major Wiley acted as assistant engineer for the Brooklyn Water Works, the Croton Water Works, and the Philadelphia and Reading Railroad, but it is as a publisher of books for use in the training of engineers that he has been of the greatest service to the profession.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN extra general meeting of the Institution of Mechanical Engineers was held on Friday last, the 8th inst., at Storey's-gate, Westminster, when Sir Vincent Raven, the President, occupied the chair.

STEAM NOZZLES RESEARCH.

In opening the meeting, Sir Vincent Raven referred to the work that had already been done by the Steam Nozzles Research Committee of the Institution, with the assistance of the British Electrical and Allied Manufacturers' Association and the Department of Scientific and Industrial Research, and prior to calling upon Professor G. Gerald Stoney, F.R.S., to present the Report, he invited the chairman of the Committee, Captain H. Riall Sankey, C.B., to make a statement regarding the work of the Committee.

Captain Sankey stated that a year ago they had promised that the Fourth Report would be presented at the end of the present session. That had been done, but it had thrown a great amount of work on Professor Stoney and Mr. Telford Petrie, to whom the Committee were most grateful, as he had no doubt the members would also be. The thanks of the Institution were also due to the B.E.A.M.A., for their interest in the work and the valuable contribution they had made towards the funds.

Professor G. Gerald Stoney then presented the salient features of the Report in a few brief but lucid statements, and showed the place of the latest experimental work in the general scheme embarked upon at the formation of the committee. We commence to reprint this report, abridged, on page 617 of this issue.

Mr. H. M. Martin opened the discussion, remarking that, as mentioned in the Report, the original programme of tests had been completed, and it seemed opportune to inquire what definite additions had been made to our stock of knowledge. At the outset he had not been sanguine that they could do anything more than confirm the results of previous workers. It seemed hardly possible that any points of real importance could have escaped observation. The hardly possible, however, turned out to be the actual fact, and the Committee might confidently claim to have thrown some entirely new light on nozzle phenomena. There was, indeed, one matter which seemed to indicate that the German observations were not wholly reliable, since it was impossible to reconcile the estimates of nozzle efficiency made by Christlein with the actual performance of Parsons' turbines. His impression was that the German observers, having made experiments at high speeds and found a maximum of efficiency at or about the velocity of sound, assumed that they could safely extrapolate down to zero velocity. The classical experiments of Osborne Reynolds on pipe friction might have provided a warning against such a procedure, and the Committee's own research had definitely shown that, so far from the efficiency diminishing continuously as the speed was reduced below that of sound, it rose to a second and higher maximum at very low speeds of efflux. He had suggested an explanation of this in discussing the Second Report. Another matter of great importance was the discovery, due to the persistence of Mr. Petrie, of the "flapping effect." This seriously influenced the efficiency of nozzles with thick parallel division plates. He had always felt that this method of construction was bad from the standpoint of hydraulics, and that the Parsons blade must be the better form. It had now been proved that, with parallel division plates, a partial vacuum formed over the wide "lands" at the discharge edges of the blading, and this diminished the efficiency. On this matter he wished to add that he was not satisfied with the experiments

on the multiple straight nozzles. He strongly suspected that a partial vacuum must have been established in the interspace between the jets, and that the true efficiency was a little higher than the recorded figures indicated. He was very glad, therefore, that experiments were also made on single nozzles. It would be noted that these latter experiments proved the absence of any "distance effect."

Mr. Martin believed that Professor Stoney was the first to discover that if a simple flat plate were used to take the impulse of a steam jet, the force observed varied with the distance between the nozzle and plate. This showed that such a procedure must be inherently unreliable. On the other hand, the impulse method of testing has some marked advantages. The whole of the high-pressure portion of the apparatus was "static," and there was no difficulty in using spacious nozzle boxes. Indeed, he now thought that the committee had not taken full advantage of this possibility, and that it would have been well to have made the nozzle box still larger. By the experiments at Rugby it was shown that, by facing the impulse plate with a thick porous pad so as to take the velocity out of the steam before it cleared the cage, the problem could be solved. The Manchester pad, however, differed in size from that used at Rugby, and it was well therefore to have its efficiency confirmed by the "distance" tests. So far as he knew, in no other apparatus had it been possible to cover so wide a range of velocities. It should be borne in mind, however, that the impulse type of tester was not suitable for tests in which speeds greater than that of sound were developed in jets from convergent nozzles. The tester used was designed only for the conditions met with in ordinary practice.

Mr. B. Pochobradsky said he was generally in agreement with the conclusions drawn by Professor Stoney. With regard to the built-up impulse nozzles, the efficiency obtained was the highest so far reached in the tests, but it was thought that the accuracy of observation did not quite reach the expected limit. He thought that the instability of flow with these nozzles was due to two causes, one of which was the sharp edge which was cut off at the inlet of the nozzle. This was not done intentionally; that type of nozzle had been available and it had been impracticable to wait until the correct form could be made. The second cause of instability he imputed to the fact that there were only three steam passages in the block (see Fig. 9 of the Report, page 618). An inspection of that illustration led him to conclude that each of the passages at the inlet was somewhat different. The finish of the nozzles was good; the passages were machined all over, and he thought that the steam on the convex side had been flowing at a higher velocity than would have been the case in an unmachined nozzle and probably that accentuated the instability of the flow. The superheat ranged from about 56 deg. C. at the lower velocities, up to almost 100 deg. C. at the higher velocities. If correction were made for superheat, it would be found that still higher efficiency would be obtained with the nozzle. He had plotted a corrected curve, and had found that, at 400 ft. per second, the velocity coefficient was 98·5 per cent., and, at 1,800 ft. per second, 96·4 per cent.

By plotting the corrected values against all the curves for the various nozzles, the superiority of the particular nozzle considered would be found. That superiority was accentuated in the higher velocity tests where the difference in the velocity coefficient was at least 2 per cent.; in other words, the efficiency of the nozzle at high velocity was about 4 per cent. greater than with any other nozzle tested. The main reason for this resided, he thought, first of all in the finish of the blade. For that only one comparison had been available, viz., the tests of Parsons nozzles, which he believed were machined smooth all over. Yet the Parsons nozzle did not give so good a velocity coefficient, so that the finish did not quite explain everything. A further explanation of the superior efficiency, in his opinion, was in the easy flow, the radius of the nozzle being larger than in most of the nozzles tested. Also, the area from inlet to throat varied gradually throughout.

Mr. J. E. Shakeshaft mentioned that it had been found that the form of entry from the steam chest to the nozzles had a decided effect on the behaviour of the nozzle, and, in certain cases, modification of the entry from the steam chest to the nozzle considerably improved the efficiency. He then indicated, by means of sketches, how by an increase in the radius of curvature at the inlet to the nozzle, the shock effect, which was unavoidable in the pressed-plate type of nozzle, could be reduced. In further work, tests bearing on this radius of curvature might advantageously be carried out. His second point related to the effect of superheat on the velocity coefficient referred to in Fig. 17 of the Report. From that figure it would be seen that, for the range of superheat employed, there was, at low speed, a difference of about 1 per cent. in the velocity coefficient, this decreasing with increasing steam speed. In view of the wide range of temperature over which modern turbines worked, he urged the advantage of conducting further tests dealing with the effect of superheat on nozzle efficiency. He desired also to reiterate a suggestion made at a meeting in Manchester last year, namely, that the Committee might consider the incorporation in their apparatus of some form of temperature control. The text of the Report stated that it was to be noted that there was no appreciable difference to be expected between 6½ in. and 1½ in. away from the nozzle. He had been struck, on looking at Fig. 14, by the fact that it would be justifiable to draw a mean line, in the case of the top curve, at about 98½ per cent. In curve 31, the dotted line was a fair average of the points shown, and in curve 32 the line might be drawn at about 97½ per cent. Although Professor Stoney had stated that those test points were within the range of accuracy of the apparatus, he felt that another conclusion might be drawn from the points as plotted, and that the distance from the plate had some effect on efficiency.

Mr. Telford Petrie remarked that he would like to make one or two comments on questions raised by previous speakers. Mr. Pochobradsky had rightly pointed to his design of nozzle as one of the most efficient that had been tested in the course of the work. In the rather wide band appearing in curve 33 of Fig. 10 (see page 619), it would, he thought, be found that the points were all well within that band, and he felt that the same degree of accuracy was obtained in that case as in the other nozzles. It was scarcely fair, however, to claim this, for the reason given in the Report, namely, that in the actual reading the mercury column was moving up and down. He agreed as to the superheat effect, but this was not embodied in the final review, which was intended to be more a review of the actual group of nozzles tested under the programme. It would have been quite right to have put in the curve with the corrected superheat in each case, when it would have come out at the figures given by Mr. Pochobradsky. Mr. Shakeshaft was right in pointing out that Fig. 14 of the Report might fairly be interpreted as showing that there might be a distance effect, but it was inside the limits of the experimental accuracy, and, therefore, need not be taken into account. Mr. Shakeshaft had also referred to discharge coefficients. As a matter of fact, he had not, except in one case, discovered the "minimum portion" given in Mr. Shakeshaft's curves during the discussion on the Second Report. He had found, however, that, between 800 and 1,000 ft. per second, the discharge became unstable.

Turning now to his own views of the tests, Mr. Petrie referred to Fig. 20 of the Report, showing the mean results of the curves. He was most impressed by the fact that the upward bend at low velocities occurred earlier in the graph in the case of the 0/1 throat than in that of the 3/1 throat, the figures being approximately about 700 ft. and 900 ft. to 1,000 ft. The length of throat did seem to affect the upward bend. Apparently, some disturbance was going on inside the nozzle, whether the latter were good or bad. This disturbance seemed to him to be caused by the conditions of entry. He did not think anyone could design a nozzle to give perfect conditions of entry throughout a large range of velocity. Provided that the disturbance were well inside the nozzle, accompanied by full-bore discharge of the steam from the nozzle, the effect did not seem to matter. That conclusion was borne out by the tests with the Parsons' nozzle.

Mr. L. St. L. Pendred was impressed by what seemed to be an extremely bad entry to the nozzle. Referring to Fig. 2B of the report, it appeared that the steam had to turn sharply round the corner, and, in finding the lowest nozzle, had to pass in front of the other two, conceivably creating disturbance in that neighbourhood. Guide plates should have been used and arranged in some convenient form for directing the steam. He wished also to ask why Mr. Martin thought that thick walls would cause more disturbance than thin walls; he thought the disturbances referred to could have been avoided by proper stream-line formation as in the case of Mr. Pochobradsky's nozzle. It did not seem to him that it much mattered how thick the walls were, as each nozzle must be regarded separately.

Mr. Martin here remarked that he had referred to thick parallel plates. With present knowledge it would have been better to have had a bigger supply pipe to the nozzle. The point was really concerned with the velocity of the steam approaching the nozzle; the lower that velocity, the less the disturbance. He did not think the disturbance would occur if the size of the nozzle box were increased.

Professor G. G. Stoney then replied to the discussion. He expressed his agreement with the suggestion that, in making a new nozzle tester, the supply pipe should be enlarged; the whole apparatus would be better if made on a bigger scale for the same size nozzles. One trouble of the turbine designer was to cut down length between the inlet and outlet faces of nozzles. The angle of exit of the steam was found by the relationship of the width of the opening to the pitch of the nozzles and was not the nozzle angle. The plates in nozzles had not only to guide the steam but to carry the pressure, so that the problem of getting the nozzle plates strong enough was a very serious one in the case of large turbines; in this connection, thick plates were a great advantage. Indeed, some manufacturers had adopted the device of making their nozzle plates with the tops turned over to strengthen them.

Professor Stoney regarded Mr. Pochobradsky's explanation of instability as very probably right, and with a larger number of nozzles than three the defect could be avoided. Mr. Pochobradsky had argued that the area should vary uniformly throughout. He had not plotted the variation of area for Mr. Pochobradsky's nozzle, but from what Mr. Pochobradsky had said he concluded that the area would be much more uniform than with the others tested. In reply to Mr. Shakeshaft, Professor Stoney said that the question of fitting a superheater was under consideration. One thing to be remembered was that the tests were taken with the impulse blade 2½ in. away from the nozzle, whereas in an actual turbine the blades would be ¼ in. from the nozzle. Therefore, it did not follow, in every case, that the results obtained with the tester would be the same as were obtained in an actual impulse turbine. For testing fully, a complete element was necessary, consisting of a nozzle and a bladed wheel. The bladed wheel could not be stationary, but must be running, as, if stationary, the shape of the blades would have to be very materially altered to get the steam to enter them properly. The difficulties of experimenting on a single-impulse wheel, generally about 24 in. to 40 in. diameter, and running at 3,000 revolutions, were considerable. He had found that a small wheel about 10 in. or 12 in. in diameter, running at 12,000 revolutions, would be much better. He made out that it would be easy to get from that, working down to atmosphere, about 60 kw., and the windage, which was serious in all cases where a large wheel was used, would be quite small in this example, namely, about ¼-h.p.

Sir Vincent Raven commented upon the double advantage, scientific and practical, of the research work covered by the Report. The thanks of the Institution were due to the Committee, under the chairmanship of Captain Sankey, for the hard work they had done. He also referred, in congratulatory terms, to Professor Stoney's personal labours. A vote of thanks to the Chairman and

members of the Research Committee was then put to the meeting and passed by acclamation.

The Secretary then announced that an extra general meeting would be held on Friday next, May 22, when a paper on "Some Tests of a Two-Stroke Cycle Oil Engine" would be read by Professor E. A. Allcutt, M.Sc., of Canada.

The report of the Nozzles Committee was also discussed by the Manchester branch of the Institution on the preceding evening.

It was opened by Mr. L. V. Cox, with a communication from Mr. K. Baumann, who said that it should be borne in mind that the tests did not necessarily represent the efficiencies of the nozzles as actually used in practice. In the tester there was a space of 2½ in. or more between the nozzle and the pad, whilst in turbines the distance between the nozzle and the blades was only about ¼ in. Hence, such matters as instability of the flow or lack of uniformity in the efflux angle might be more important in practice than in the tester. What was required to know was the effect of the combination of nozzles and blading, but there were difficulties in devising a satisfactory tester for this purpose, since a correct comparison of relative nozzle efficiencies could be obtained only when working with moving blades. At the same time, the static tester would no doubt prove a very useful apparatus, and his company had accordingly installed one similar to that used by the Committee, and they proposed from time to time to publish the results obtained. Referring to the tests of the built-up type of blades, Mr. Baumann said that this type had been used by his company 15 years or more ago, and Fig. 1, annexed, represented those adopted for the first stage of the Dalmarnock turbines installed in 1919. The relatively higher efficiency of this type was largely due to the better finish. The instability noted in the tests might possibly be a disadvantage in actual turbines. This, however, could only be settled by definite trial, and, in any case, it could be avoided by giving the nozzle a definite throat. An advantage of the built-up type was that it could be given any desired shape, so as to combine efficiency and strength. The use of the type for intermediate nozzles depended on the price users were prepared to pay. With fuel as cheap as it was before the war, the use of such nozzles throughout the turbine would not have been justifiable, but as matters stood to-day manufacturers were prepared to quote for machined nozzles at least throughout the H.P. end of the turbine, and there would be a corresponding improvement in efficiency.

Mr. Norman Elce, who followed, described some tests made by the Metropolitan-Vickers Company with two of the identical sets of nozzles used in the committee's tests. In one case, that of the multiple-jet straight nozzles, the figures recorded by the Committee were practically reproduced, but there was a difference of about 1 per cent. in the velocity coefficient of the impulse nozzles with thick division plates chamfered at the discharge edges. This was shown in Fig. 2. No explanation of this discrepancy had yet been found.

No "distance effect" was found with the Metropolitan-Vickers tester, the results being the same whether the nozzles were 4½ in. or 2¾ in. from the pad. The policy of the Committee had been to publish actual test results without elaborately analysing them, but the speaker thought that with the programme now completed it would be well to attempt some rationalisation of the tests. The factors of importance were, he thought, the approach to the nozzle, the shape of its cross-section, the surface finish, the form and rate of convergence, the curvature of the nozzle axis, and its actual dimensions. He had plotted the curves, reproduced in Fig. 3, showing how the area of the impulse nozzles represented varied with the distance along the stream line, and also the variation in the direction of flow. The dotted curves represented the rate of change of area and of the direction of the flow. He suggested that it might be that, for best efficiency, a certain rate of change of curvature would be found to coincide with a particular rate of acceleration of the steam speed. The importance of curvature was emphasised by the shape of the curves of the velocity coefficient. With straight nozzles there was a rise of the coefficient at low speeds, and, presumably, had it been possible to carry out the experiments at still lower speeds the same thing would occur even with the 12 deg. nozzles. Mr. Martin's suggestion that this rise was due to the flow becoming viscous at these low speeds was well known. It had been objected that the velocity at which the change occurred did not agree with that found in experiments on straight pipes. In a nozzle, however, it had to be remembered that the velocity of flow was not merely the velocity at exit but varied from nearly zero at the entrance to, say, 150 metres or more at the outlet. The losses in the earlier part of the flow would thus be quite

Fig. 1.

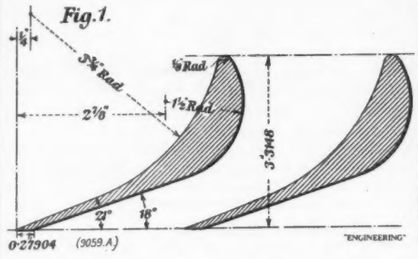


Fig. 2. 20° THICK PLATE IMPULSE NOZZLE. FLAT CHAMFERED. 9/1 THROAT.

Steam Nozzles Research Committee's Tests Indicated thus: •
Metropolitan Vickers Tests at 4½" Indicated thus: ○
Metropolitan Vickers Tests at 2¾" Indicated thus: •

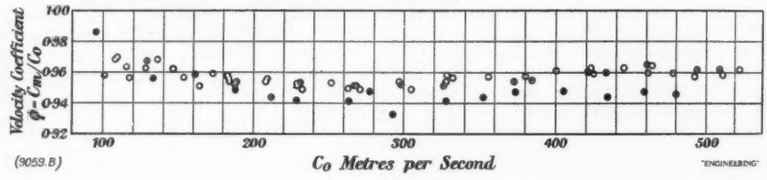
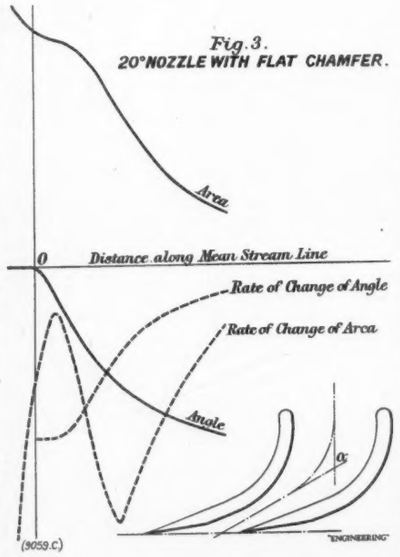


Fig. 3.
20° NOZZLE WITH FLAT CHAMFER.



different in character from the fully turbulent losses later on.

Mr. Ashworth said that discharge coefficients had been worked out for each of the nozzles tested, but the results did not generally conform to a simple straight-line law. It had accordingly been found necessary to calculate the coefficients for each individual test.

Mr. J. M. Newton considered that the report would be valuable to all interested in turbine design. A point of great practical importance, which had been brought out in the tests, was that as high an efficiency could be obtained with thick as with thin division plates provided the edges of the thick plates were chamfered. This simple result gave the designer an immense amount of freedom in designing nozzles of high efficiency, enabling him to combine this with mechanical strength.

Mr. E. W. Beeley said that, with 12 deg. thin plates, the curves of nozzle discharge seemed to indicate a break in the type of flow at a speed somewhere between 700 ft. and 900 ft. per second. This was not found with the Mellanby nozzles, which gave a continuous curve.

Mr. Telford Petrie said that the discussion on the various nozzle reports had been of great advantage to the Committee. He agreed with Mr. Baumann as to the difficulty of testing nozzles under conditions exactly similar to those in which they were used. He was not confident that the tests showed absolute values, but he hoped that, relatively, they were reliable. As for the instability found with the built-up type of nozzle, he thought it was due to the lack of a throat and the possibility of a direct "blow through," the nozzles being of such a form and spacing that it was possible to see directly through them. The question of finish was a very debatable one. Many builders attached great importance to it, but the results so far obtained in the tests were disappointing; they were, however, hoping to investigate the matter further. The cage used by the Metropolitan Vickers Company was larger than that used in the tests of the Committee, and the latter were making up a larger one themselves. As had been mentioned, discharge coefficients were often very irregular between speeds of 700 and 1,000 ft. per second. All had a tendency to rise as the speed increased from 1,000 to 2,000 ft. per second.

Professor Stoney brought forward the same suggestion as to tests on a small turbine that he made in the discussion in London, as reported above. He agreed with Mr. Baumann that the conditions in the tester were not identical with those existing in practice, and caution might be required in applying the Committee's figures to the latter. Generally, however, the results would be valuable, particularly the conclusion that high efficiencies could be obtained with thick plates. The suggestion of chamfering the outlet edges of these was due to Mr. F. Samuelson. With regard to the point at which turbulence commenced, the corresponding value of the coefficient $\frac{VD}{\nu}$ was much larger with nozzles than it was with pipes, and probably it also varied with the shape of the nozzles.

GRAIN CARRYING, ss. "ROCKCLIFFE."—The fifth ship built to the order of the Cliffe Steamship Company, Limited, by Messrs. John Readhead and Sons, Limited, of West Docks, South Shields, the screw steamer Rockcliffe, recently carried out a successful trial trip in the North Sea. The vessel has a length of 364 ft. between perpendiculars, a breadth of 50 ft. 6 in., and a depth of 26 ft. 0½ in. She is of the single-deck type, with poop, bridge, forecastle, and also a steel centre-line bulkhead, and the large clear holds, provided with shifting boards and feeders, are designed for carrying grain. Water ballast is carried in the double bottom and after peak. Adequate auxiliary equipment is fitted for the rapid loading and discharging of cargo at large hatchways, and steam heating, electric lighting, and ice chambers for the preservation of perishable goods are installed. The machinery, constructed by the builders, consists of engines of the triple-expansion type having cylinders 25, 42 and 69 in. in diameter, with a stroke of 45 in. Steam is supplied by two boilers working at a pressure of 180 lb. per square inch. A large donkey boiler is also provided. The Rockcliffe is built to the standard of Lloyd's highest class and complies with all the latest requirements of the Board of Trade regarding life saving and ventilation. The vessel has been fitted with wireless-telegraphic equipment of the latest type.

THE ROYAL SOCIETY SOIRÉE.

THE exhibits and demonstrations of the first Royal Society soirée of this year, which was held last Wednesday, in the fifth year of the presidency of Sir Charles Sherrington, O.M., were not particularly numerous, but were rich in interest both to the physicist and engineer and to the biologist. Instead of the usual evening discourse, three kinematograph demonstrations were made of a film which showed the incessant and irregular motions of small particles in liquids and gases, which are known as Brownian movements. The film, which has been prepared from photographs taken by the aid of a super-microscope, was of a remarkable character, the field which filled the screen actually covering but a very small fraction of a millimetre. Explanations of the film were given in turn by Sir Ernest Rutherford, Dr. Aston, and Dr. J. Chadwick.

In describing some of the exhibits we may first mention some of historical interest, such as the early compasses from the Admiralty Compass Observatory, comprising the first patented compass of Dr. Gowin Knight of 1766, Schmalcalder's first prismatic compass of 1812, Crow's first liquid compass of 1813, and the compass which James Ross used in his Antarctic expedition of 1839. Some of the illustrations to the early history of physical instruments, exhibited by Professor E. N. da C. Andrade, were mentioned in our comments on his lectures on "The Evolution of the Scientific Instrument"*; he also showed a model of the aerial telescope of Huygens, consisting of a Huygens eye-piece connected by a string with the objective lens mounted with its short tube on a stand; the observer holds the eyepiece to his eye, pulls the string and adjusts his position until he sees the object. The earliest English telescope and the oldest optical instrument of authentic date, the Galilean telescope of Jacob Cvnigham, 1661, shown by Mr. George H. Gabb, is a curious trumpet-shaped tube, made of wood and red leather, and focussed by the aid of two draw tubes. The Lucernal microscope which Dr. R. S. Clay and Mr. Thomas H. Court exhibited, is a big, elaborate instrument mounted on a collapsible mahogany stand; it was made by Samuel Washbourn, of London, about 1800, and fitted with a mechanical stage adjustment by means of Hooke joints and special focussing and illuminating contrivances. The simple models of the pendulums of Galileo, Huygens and Euler, which Sir George Greenhill exhibited together with large diagrams of exact algebraic gyroscopic motion of five- and tenfold symmetry, have also an historical interest. Professor J. G. Gray's gyroscopic tops and pendulum, though quite modern, were utilised to exemplify some old experiments. The early radiotelegraphic apparatus, which the Science Museum exhibited, belong to the last three decades; there were apparatus used by Sir Oliver Lodge for demonstrating Hertz waves in 1894, Mr. Marconi's first tuned transmitter of 1899, and Professor Fleming's early and modern thermionic valves.

Most of the new apparatus which we have to notice was in a sense electrical, and even with the fused quartz ware of the Thermal Syndicate, Limited, electricity is an essential item in the manufacture. The display included lamp and X-ray bulbs, bars for resistors, tubular envelopes for valves, &c. The corrugated quartz valve tubes shown, which were cylinders 2 ft. 7 in. long, 8¼ in. diameter, weighing 7½ lb. each, with a wall thickness of ⅛ in., are said to be the largest one-piece articles ever made in fused quartz. Though the quartz is disintegrated for fusion, it is essential that the clearest rock crystals, free of bubbles, be chosen as raw material for the best ware of 99·8 per cent., whilst opaque silica ware may be obtained from sand. There is a strong demand now for inexpensive silica tubes free from bubbles.

Professor W. M. Thornton's miner's electric lamp differs from the ordinary miner's electric lamp by serving also for the detection and measurement of fire damp. The lamp body is a case of pressed steel containing the battery; the flat cover is provided on the inside with contacts for a two-way switch; on the cover is mounted the glow lamp which in the one switch position serves for illumination and in the other for detection. One of the usual four pillars surrounding the lamp is replaced by a perforated brass tube containing the detector devices which are adjusted by a head screw and comprise a platinum spiral through which a small current is flowing. When the air entering through the holes into the brass tube (which is packed inside with two layers of wire gauze) contains methane, the gas is burnt, and this lamp branch circuit is thermally closed. Dr. Thornton showed this by blowing some petrol vapour against the brass tube; the lamp (with the switch in the detector position) flashed up and went out again after the little methane or hydrogen in the vapour had been consumed. The rate of burning is proportional to the gas percentage.

The Cambridge Instrument Company demonstrated that their Shakespear katharometers, the uses of which we have described on other occasions, can be utilised for recording very small amounts of carbon dioxide, such as a fly or a growing plant will exhale. A blue bottle fly was kept in a small glass tube joined at the top to a katharometer. This is made in one size only, the cells containing the standard gas and the gas mixture to be tested having a capacity of about 0·5 cub. cm.; in each of these cells is stretched a fine spiral of platinum, which is heated by a small current; the rate of cooling (observed or recorded) depends upon the thermal conductivity of the gas mixture. With the fly the CO_2 curve rose, in steps, to 10 per cent. in 5 hours and remained steady afterwards—why, is not clear. In other experiments the fly had continued to live in air with 15 per cent. of CO_2; the steps in the curve probably marked the efforts the fly made to escape. Other apparatus showed the liberation of traces of CO_2 from decomposed carbonates and also from laurel leaves and from a germinating bean. Professor A. V. Hill has used the katharometer for the analysis of the alveolar air. Another experiment exemplified by means of a katharometer the "thermal diffusion" which Professor S. Chapman observed in 1911, and to which attention has recently been drawn. When a temperature gradient is set in a gas mixture, the light molecules (*e.g.*, of hydrogen) travel to the hot part, and the heavy molecules (air) to the cold; this is a temporary effect, which is soon balanced by ordinary diffusion. The effect was demonstrated with the aid of a brass tube, bent to a horseshoe, and filled with hydrogen-air mixture. The tube was heated by means of an external coil at one spot, so as to create a temperature difference of about 50 deg. C. between this spot and the opposite one; branch tubes which led from these two spots to the katharometer showed the accumulation of the hydrogen near the hot end and would indicate temperature difference of 1 deg. C.

The Brown-Firth Research Laboratories, of Sheffield, showed how by means of thermocouples (used up to 1,200 deg. C.), inserted to different depths, and optical pyrometers for higher temperatures, the distribution and penetration of heat through steel ingots of 30 tons had been investigated, and the heterogeneity of large masses of steel bars been demonstrated. That character was further proved by macro-etchings which show large and small crystals in close juxtaposition. The other exhibits of the firm illustrated the remarkable properties of some non-corrosive steels, notably a 0·1 to 0·2 carbon steel containing 18 per cent. of chromium and 8 per cent. of nickel, for which the unfortunate name of "staybrite" has been proposed. One specimen of this steel had kept bright for months in sea water; another had travelled from England through the Panama Canal and back while fixed in a foreward porthole.

The nickel spatulæ, which Professor F. D. Chattaway, F.R.S., of Oxford, exhibited, have been found very useful in the organic chemical laboratory, because they are not attacked by anything except the strongest acids and nitric acid. Rods of the purest nickel are rolled out to a width of 1 cm., and the end of the spatula is bent up at an angle of 120 deg.

(To be continued.)

* ENGINEERING, April 3, page 407 *ante*.

LABOUR NOTES.

CRITICISM by organised labour's rank and file of the proposals relating to working hours and wages submitted to the unions by the Engineering and Allied Employers' National Federation is, broadly speaking, running along three main lines. The Metal Workers' Section of the National Minority Movement is opposed to the whole scheme and insistent on the demand for, amongst other things, a wages increase of 20*s.* per week. Rejection of the employers' proposals would not necessarily mean a stoppage of work; but insistence on a wages advance, without any readjustment of working conditions, certainly would. The industry could not bear any increase of its production costs; its position in that respect is, as a matter of fact, worse than it was a year ago. But it need not be ignored—happily, it is not ignored by the majority of reasonable men—that a stoppage on this or any other issue would suit the N.M.M., which, as is natural in the case of an instrument of the Communist Party, desires less the immediate welfare of the workers than it does "the revolution" which is its ultimate aim. The Labour Movement's sounder men may, however, safely be left to see that the workers' immediate welfare is not sacrificed for the sake of something much less tangible and much more remote.

Another line which criticism is following is orthodox, although those who are arguing along it are unaccountably irresponsive to the pressure of facts which are outside the area of their own particular activities. With them, the 48 hours' week has become a sort of article of faith in trade unionism to which adherence is absolutely imperative. Nobody in the ranks of the employers wishes either unduly to increase working hours or to depress working conditions; that is a plain statement which trade unionists can easily verify for themselves. But if all his foreign rivals, with the assent of the unions to which their workmen belong, put in longer hours of labour, and, thereby, bring production costs down to a level with which the British employer cannot compete, a situation is created which adherents to the principle of a 48 hours' week, obviously, cannot reasonably refuse to face. As is indicated further on in these Notes, Mr. Ernest Bevin has no illusions on this point. He suggests that an international trade union convention should be held to deal with the matter, and expresses the belief that if it is found impossible to arrive at unity regarding working hours, British trade unionists will have no alternative to facing the issue involved. When the matter is put to them in that plain way, the majority of workers unmistakably agree that it would not be fair to themselves nor to their families to refuse to work longer than 48 hours per week, while their fellows in competing countries were working from 54 to 60 hours per week.

The third line of criticism is that which the workmen in the industry are themselves following. They are applying the proposals to their own particular cases, and by reckoning the hours to be added at overtime rates, making out that they would be losers rather than gainers by the re-adjustment. The fact is, of course, that the earnings of day-shift time workers would be increased by slightly over 5*s.* per week, and those of day-shift piece-workers by considerably more. The great bulk of the industry's workers are on day shift. Many men would, therefore, be large gainers, whereas under present conditions comparatively few men work overtime, which is, besides, only intermittent. Under present conditions, it should be remembered, overtime and night shifts are unprofitable. Employers cannot afford to work them, and the industry's unemployment figure is, as a consequence, high. Under the new proposals, with night-shift rates and conditions easier, night shifts would be profitable, and work would be available for more men. It is hoped that when the trade union executives meet in London on Wednesday next these important facts will not be overlooked. The great need of the engineering industry at the moment is lower production costs, and the proposal which has been made is, in effect, an invitation to the unions to co-operate in an effort to reduce them. If the men are sacrificing anything in modifying their adherence to the principle of the 48 hours' week, the employers are also foregoing something. They are not asking the men to work the added hours for nothing, as some of their foreign rivals are doing; they are paying them for the extra labour and, in addition, increasing the war bonus by 2*s.* per week.

In September, 1923, the National Committee of the Amalgamated Engineering Union passed a resolution "strongly" expressing the opinion that "the Government should put in hand immediately engineering projects, and assist in developing such projects of public utility and importance, thereby finding employment for skilled mechanics." The executive council was instructed "to seek an early interview with the Prime

Minister and make representations accordingly." Owing to various circumstances, beyond the control of the executive, the interview with the Prime Minister did not take place until Tuesday last. At its close an official communication was issued from 10, Downing Street, which stated that the Prime Minister, accompanied by Sir Arthur Steel-Maitland, Minister of Labour, and Colonel Wilfrid Ashley, Minister of Transport, had received the members of the executive of the Amalgamated Engineering Union, who had asked to lay before him the terms of a resolution on the subject of the severe and continued unemployment in the engineering trade. The members of the deputation were Mr. J. T. Brownlie (chairman of the executive), Messrs. J. Kaylor, W. H. Hutchinson, F. Marsh, P. Dickinson, H. Berry, A. Lorimer, A. B. Swales, and A. H. Smethurst (general secretary). The text of the resolution was given in the statement, which proceeded:—"Mr. Brownlie dealt with various points arising out of the resolution and concluded with an appeal to the Government to consider projects which could be put in hand of a kind that would give employment to skilled mechanics, including Empire development (particularly railways), electrification of British railways, bridge building, and the improvement of trade facilities with Russia. The Prime Minister in reply dealt in detail with the various points raised by the deputation, indicating that the Government fully appreciated the severity of unemployment in the engineering trade, and would lose no opportunity of forwarding any practicable plan that seemed likely to lead to its alleviation."

In the course of an interesting article in *The Burntisland Shipyard Journal*, Mr. A. L. Ayre, the chairman and managing director of the Burntisland Shipbuilding Company, expresses the opinion that, instead of losing money on their Furness Withy contracts, the Deutsche Werft and their allied organisations are likely to make a considerable profit. The German price was 153,000*l.* per ship, and it compared with 213,000*l.* quoted by a British yard. According to statements in the Press, this meant that German shipbuilders could beat British shipbuilders by 60,000*l.* per ship. Mr. Ayre points out, very truly, that what should have been emphasised was that the whole of the German industries, from the coal and ore stage up to the completed ship, could beat the corresponding range of British industries by that amount, in consequence of the lower wages, lower standard of living, and lower cost of living that obtain in Germany.

It is generally agreed, Mr. Ayre says, that of the total cost of constructing a ship at least 80 per cent. is spent in wages from the coal and ore stage upwards. Out of the British price—213,000*l.*—the total amount of wages spent throughout the various stages would, therefore, have been about 170,000*l.* But if throughout the British industries wages of no greater amount fell to be paid than are paid in Germany, the wages cost would have been halved—would have been 85,000*l.* less, that is—and the British price would have become 128,000*l.* Because of the low wages paid in Germany, the German yard with its 153,000*l.* will be, Mr. Ayre reckons, relatively about 25,000*l.* better off than our people would have been had their price been accepted.

The Industrial Court has issued its award in a reference relating to the wages of certain shopmen employed on the Great Northern Section of the London and North Eastern Railway. The Court was asked by the National Union of Railwaymen and the Boilermakers' and Iron and Steel Shipbuilders' Society, representing the men concerned, to determine for the purposes of Schedule "C" of Award No. 728, the rate of pay of angle-iron smiths, platers, and riveters employed in the section. The present time or day rates of pay are: angle-iron smiths, 48*s.* per week; platers, 46*s.* per week; and riveters, 46*s.* per week. With one or two exceptions, the men are all piece-workers. The Court decided that the rates of pay of the men concerned for the purposes of the schedule shall be: angle-iron smiths, 49*s.* per week; platers, 47*s.* per week; and riveters, 46*s.* per week.

The application of the Weavers' Amalgamation for revised rates of pay has been refused by the employers in the cotton industry. In their reply the employers point out that Lancashire is suffering from its inability to produce cloth cheaply enough to encourage customers. If the operatives' application was put forward as the fundamental basis of payment to weavers, it would, they say, considerably increase the cost of production, and also seriously reduce output. "Your application," the employers state, "appears to be designed to undermine and eventually destroy the standard piece-price rates of wages, which have been the basis of payment for over sixty years. The employers regard piece-rate systems as being absolutely essential to the cotton industry."

According to an official statement by the Miners' Federation of Great Britain, it is hoped that the Conference with the other trade unions, which have been sounded regarding the formation of a new industrial alliance will take place on June 4. The organisations which are to be invited to the meeting will include, it is understood, the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, the National Transport Workers' Federation, the Transport and General Workers' Union, the Amalgamated Engineering Union, and the Federation of Engineering and Shipbuilding Trades. The Conference will lay down the general principles of an alliance programme, and will set up a full representative committee to work out details. Later, the General Council of the Trade Union Congress will be invited to come in and "co-ordinate" the work of the alliance with that of the rest of the trade union movement.

In April, the home branch membership of the Amalgamated Engineering Union decreased from 213,341 to 212,825, and the Colonial branch membership increased from 25,544 to 25,619. The total membership is now 238,444. A decrease is recorded in the number of unemployed members; the percentage, reckoned in the usual way, is 6·91.

At a meeting on April 24 of the Engineer Officers' Panel (National Maritime Board) the position of an engineer officer transferred from a steam vessel to a motor vessel in the same ownership was defined. It was agreed that "in the case of an engineer officer transferred at his own request, or at owner's instance, from a steam vessel to a motor vessel in the same ownership, the commencing rate of pay on the motor vessel shall be the motor vessel 'begin-at' rate, provided such rate represents an increase on the National Maritime Board scale of pay to which he was entitled on the steam vessel on which he was previously employed."

The following editorial note appears in the May issue of the A.E.U. Monthly Journal:—"The attitude of the engineering employers on this wage question is certain to raise a doubt as to whether any good purpose is served by our present method of negotiation. It would appear that, irrespective of how busy certain sections of the industry may be—no matter how well able to grant an increase in wages to those employed in that section—it is not to be done, because the whole of the industry is not at the same time in a flourishing condition. This is an impossible position to us; it is rarely, indeed, that all sections of the engineering industry are busy at one and the same time. Therefore, the employers' attitude would mean that the weakest section of the industry must be the standard upon which wage rates are based. We cannot accept that proposition, and, if the present method of negotiation proves that we are unable to obtain a rate of wages commensurate with the skill demanded from our men, then we have no alternative but to scrap the existing procedure and adopt other methods." If that is the view of the executive council, and not merely that of the editor of the Journal, it is a singularly short-sighted one, for, although it is practically certain to be shared by some of the principal areas, other lower-paid districts are unlikely to see much in it to admire. In effect, the scrapping of the present procedure would be a bad thing for the poorer districts, and a considerable number of workers frankly realise that.

Addressing the annual meeting of the tinplate section of the Transport and General Workers Union at Swansea on Saturday, Mr. Ernest Bevin said that the difference on the question of working terms was so vital as to warrant them making a demand on the whole forces of international labour to state clearly where they all stood. They had the right to demand that there should be an international convention with a view to obtaining agreement. If, as a result of such tests being applied as to the sincerity of all concerned in this matter, it was revealed that any one or more of the countries were seeking to utilise lengthened hours of labour against another in order to give a competitive advantage, then the Labour movement in the countries in agreement must review their position and face the issue.

In accordance with a ballot vote of the members, the Amalgamated Union of Building Trade Workers has intimated its withdrawal from the National Wages and Conditions Council and the National Federation of Building Trade Operatives. The organisation is composed of bricklayers and masons. In a circular to the branches, it is stated that the members have been hampered, despite the prosperity of the industry, in securing payment for time lost through wet weather and other circumstances over which they have no control.

The Ministry of Labour states that on May 4, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,179,800—903,300 men, 36,200 boys, 207,400 women, and 32,900 girls. On April 27, 1925, the number was 1,187,068—910,368 men, 36,170 boys, 208,296 women, and 32,234 girls—and on May 5, 1924, it was 1,040,660—770,509 men, 36,355 boys, 199,384 women, and 34,412 girls.

A National Committee of the Amalgamated Engineering Union is to meet at Southport towards the end of this month. One of the proposals which are expected to be submitted to it has been framed by the extremist element, and has for its objects the promotion by the Union of a Bill in Parliament embodying the following features:—(1) The appointment by the Government of a Commission of Inquiry into the engineering industry invested with full powers to obtain evidence. (2) To place the industry upon a sound financial basis. (3) To establish an improved standard of wages for all workers employed. (4) The institution of the 44-hour working week. (5) The institution of shop and factory workers' control over all conditions of employment. (6) To secure the abolition of the character note system. (7) The suppression of the employers' policy of the lock-out.

The possibility of such a measure becoming law is, of course, remote; but it will probably meet its fate much earlier.

ENGINEERING TRAINING AND EDUCATION.

Society of Merchant Venturers Engineering Scholarship Scheme.—It is announced that fifteen scholarships tenable in the Faculty of Engineering at the University of Bristol, are offered by the Society of Merchant Venturers for competition between matriculated students of not less than 17 years of age. These scholarships are open, with certain restrictions, to pupils in any secondary school receiving grants from the Board of Education. Ten of the awards are reserved for the sons of officers in H.M. Services killed in the Great War. Mothers or guardians of such candidates must be in need of financial assistance. Three of the scholarships will be available only to pupils of secondary schools which are situated in Gloucestershire, Somerset, and Wiltshire, one award being allocated to each of these districts. Of the two remaining scholarships, one will be allotted only to the son of a citizen of Bethune who has passed either the B-ès-L or the B-ès-Sc., examinations, while the other, a War Memorial Scholarship, will be granted for preference to a candidate requiring pecuniary assistance who is the son of a former student killed when serving with H.M. Forces during the Great War. Further particulars regarding these scholarships may be obtained from the Registrar, the Merchant Venturers' Technical College, Bristol.

Norton and Gregory Engineering Scholarships, 1925.—The two scholarships founded by Messrs. Norton and Gregory, Limited, of Buckingham-gate, London, S.W.1, and mentioned on page 685 of our issue of November 14, 1924, have now been awarded for the year 1925. The first, value 100*l.* per annum and tenable for 3 years at Cambridge University, has been secured by Mr. Arthur Aylwin Fletcher Jones, of Monkton Combe School, near Bath; while the second, value 50*l.* per annum and tenable for three years at Cambridge University, has been obtained by Mr. Richard Peter Alston, of Clifton College.

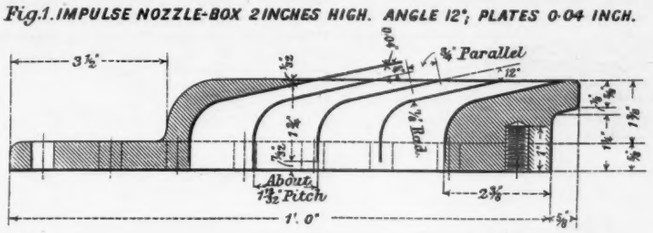
THE MANUFACTURE OF RUBBER TYRES.—To enable the public to gain some idea of the enormous organisation and resources which have become necessary for the conduct of some of the concerns which are auxiliary to our leading industries, the Dunlop Rubber Company, Limited, have had a film prepared showing the manufacture of rubber tyres, from the gathering of the rubber latex to the final testing of the completed article. The chief interest centres in the new works at Fort Dunlop, near Birmingham, with nearly 200 acres of factory buildings, where the raw rubber is treated and combined with the cotton fabric brought from the company's weaving sheds at Rochdale to form the tyres; the operations of washing, masticating, spreading, forming and vulcanising of the pneumatic tyre are well shown. Another portion of the film is devoted to the manufacture of the solid rubber tyre built up on electrically welded rings made from steel strips. Finally, the pictures show the tyres undergoing various tests, including one on a circular running track fed with loose stones which reproduce bad road conditions, such endurance trials giving proof of the minute care in the selection and use of the materials which are combined in the various processes of manufacture to form the several types of tyres.

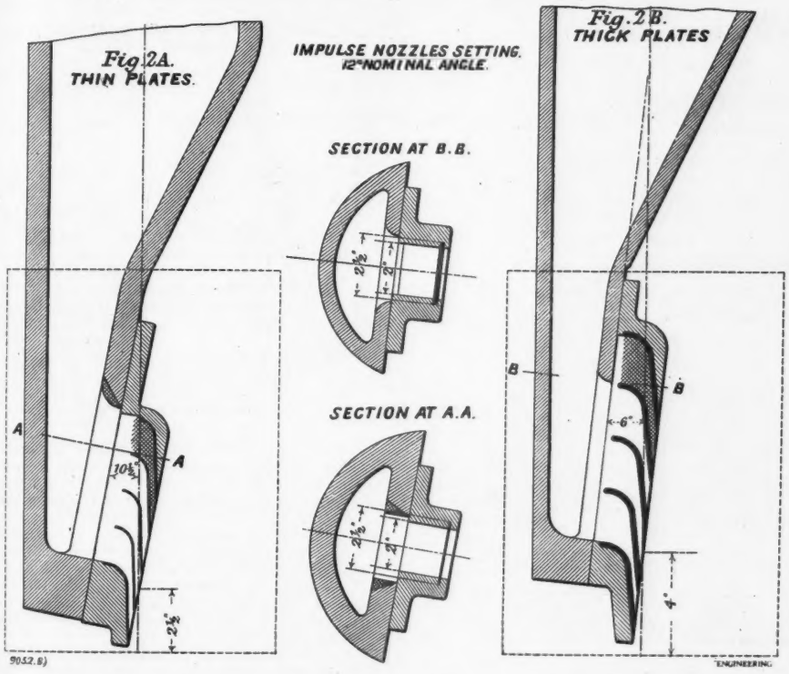
FOURTH REPORT OF THE STEAM-NOZZLES RESEARCH COMMITTEE.*

PREVIOUS reports of the Steam-Nozzles Research Committee have been reprinted in abstract in ENGINEERING—first report, vol. cxv, page 377; second report, vol. cxv, page 380; third report, vol. cxvii, page 681. The discussions on these reports were given in the same issues of ENGINEERING as the reprinted reports. In conformity with the practice we have adopted in giving the results of these investigations, we have again refrained from reprinting the tables of figures on which the graphs and deductions are based.

In the present report will be found the remaining items, 3 (*a*) and 3 (*b*) of the first main programme (see ENGINEERING, vol. cxv, page 379), together with a review of the work carried out by the committee to date. In addition, the results are given of tests to ascertain the effect of chamfer for the 12 deg. thick plate impulse nozzle, similar to those tests carried out with the 20 deg. thick plate impulse nozzle, and recorded in the third report. Further tests on efflux-angle are also included, together with an investigation on the effect of the distance between the nozzle exit and the top of the cage-mesh on the efficiency of the single straight elementary nozzle. This report also includes a series of tests on single straight elementary nozzles of different diameter from which a "constant discharge" curve has been constructed. Lastly, an impulse nozzle of a built-up type has been tested for comparison with the committee's curves.

Fig. 1. IMPULSE NOZZLE-BOX 2 INCHES HIGH. ANGLE 12°; PLATES 0·04 INCH.





Test Results of 12 deg. Impulse Nozzles (Thin Partition Plates).—The tests on this nozzle form item 3 (*a*) of the main programme of tests of the first report. The nozzle-box is shown in Fig. 1, and the setting in the tester is shown in Fig. 2A. The nozzle was set at 10½ deg. in the main tester, as can be seen from Fig. 2A, and the distance from the centre of the exit face to the top of the cage-mesh was 2½ in. with a 3/1 throat, as in all previous tests. The lever of the impact plate worked freely throughout this series and no difficulty was found in maintaining an accuracy of 1 in 500 in the various readings. A series of tests with a 3/1 throat showed that the customary rise at low velocities was absent. In fact, the curve was practically flat with a velocity coefficient which lay between 90 and 91 per cent. As this phenomenon was new in the tests of the committee, attempts were made to improve the conditions of entry by removing the portions of the nozzle-pipe shown cross-hatched in Fig. 2A. A further group of 13 tests, however, showed little or no alteration. The curve for all these tests can be seen in Fig. 3, marked Curve 17, the points obtained with the new setting being indicated with a "N."

Orders were then given for the ratio of throat-to-opening to be reduced to 2/1, as was the case with the 20 deg. nozzles, but owing to the mistake of measuring the vertical cut from the top edge of the nozzle-box, which was $\frac{1}{32}$ in. above the end of the plates, the length of throat was reduced to 2·6/1 instead of 2/1. This mistake remained undiscovered until the 0/1 throat tests were reached, so that, in the case of this nozzle, the reduction in throat was 3/1, 2·6/1, 1·6/1 and 0/1 instead of 3/1, 2/1, 1/1 and 0/1, as in all the other nozzles tested in this way. Thirty-five tests with a 2·6/1 throat are reproduced in Curve 18, Fig. 3. These are similar in character to the 3/1 throat in that they show no rise at low velocities, but even this slight reduction in throat length (slighter than was intended) shows an improvement in the mean velocity coefficient of the order of 1 per cent. A further reduction of the throat to 1·6/1 was then made, and two series of tests taken. These are shown in Curves 19 and 19A of Fig. 3. A further improvement of approximately 1 per cent. in the velocity coefficient is obtained, and the curve retains its flat character (as shown in Curve 19). It had been mentioned in the second report that the steam supply for these experiments was drawn from two different sources which depended on winter and summer conditions. In the summer months the steam came from the Bloom-street station, which was farther away, and which consequently delivered steam with a lower degree of initial superheat than when the Dickinson street station was available in the winter months. The change-over this spring occurred after the first series of tests on the 1·6/1 throat—so that up to this point the nozzle had, on the whole, been working on higher superheat. The opportunity was taken to see what effect, if any, the general lowering of superheat would have on a curved nozzle of practical shape. Hitherto, in the third report, comparative tests of this nature had only been carried out on straight elementary nozzles. The resulting graph in the second series of tests with this throat is marked 19A. The significance of these two series of tests is discussed later on in this report.

When the throat was reduced to 0/1, considerable

Fig. 3. IMPULSE NOZZLE. 12° NOMINAL ANGLE. PLATES 0·04" THICK.

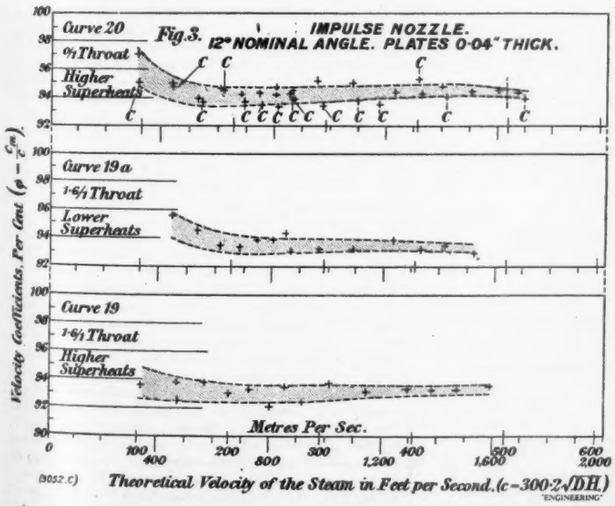
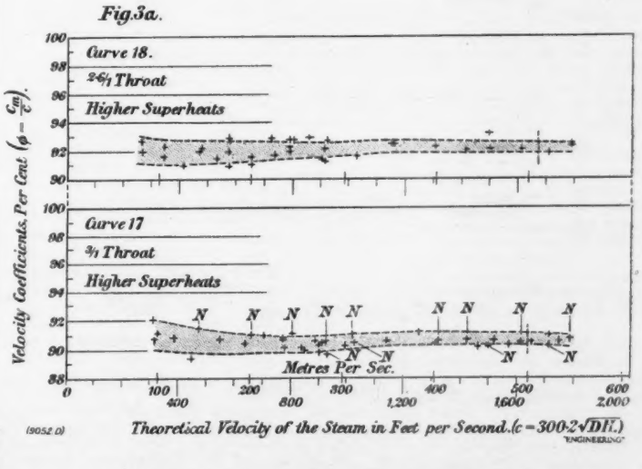


Fig. 3a.



* Presented at a meeting of the Institution of Mechanical Engineers on May 8, 1925. Abridged.

difficulty was experienced in obtaining a consistent curve. The lever balancing the thrust on the cage-plate was unstable throughout the range of tests, and various tests were rejected on that account. The nozzle was put aside until higher superheat conditions prevailed in the hope that steadier conditions could be obtained, but the improvement was not as great as had been hoped. This pointed definitely to unstable conditions in the steam jet up to at least 3½ inches away from the nozzle exit. The original setting of 2½ inches had increased ¾ inch as the throat-to-opening ratio was reduced from 3/1 to 0/1. Two entirely separate groups of tests were taken. All these tests were taken under higher initial superheat conditions and are comparable, as far as they go, with the remaining curves of this nozzle. The check series are marked on Curve 20 (Fig. 3) with a "C." It will be noted that some half-dozen tests are outside the usual band of accuracy, whilst the small improvement shown over the 1·6/1 (higher superheat) curve is accompanied by an apparent unstability of the nozzle. The tests on this nozzle, in general, are interesting in that they show less rise at lower velocities as well as a distinct improvement each time the throat is shortened. It should be pointed out that no two-nozzle tests were taken, which prevented the curves being produced beyond 1,800 ft. per second.

(Thick Partition Plates).—The nozzle-box used for the tests with thick partition plates can be seen in Fig. 4. The setting in the main tester is shown in Fig. 2B. It will be noticed that the actual length of the throat in this nozzle to obtain a 3/1 ratio of throat-to-opening entailed for the first time an alteration in the distance between the centre of the exit face and the top of the cage-mesh. In this case it had to be 4 in., in order to clear the cage-mesh below. The effect of this alteration is referred to later on in this Report. This nozzle was otherwise treated in the same way as the corresponding 20 deg. thick-plate impulse nozzle. Tests were first taken with a 3/1 throat-to-opening ratio. The results are shown plotted in Curve 21 of Fig. 5. In this case the three-nozzle tests were taken with low initial superheat, whilst the two-nozzle tests and all the subsequent curves of this nozzle were taken under the higher superheat conditions. They are shown plotted without corrections in Curve 21. The general result of this nozzle is the lowest which has yet been obtained by the committee. The back edges of the partition plates were then chamfered, as in the case of the 20 deg. thick-plate nozzle, and the results of these tests are given later. This chamfering, however, prevented a 2/1 throat ratio from being obtained, so that the next set of tests of non-chamfered nozzles were taken on a 1/1 throat-to-opening ratio. The results are shown plotted in Curve 22, Fig. 5. In this particular setting a complete test was taken with two nozzles functioning and the three-nozzle condition used as a check. The check agrees well throughout the range of tests, but the two-nozzle points are not quite so consistent. The whole curve lies considerably above the 3/1 results. The mean velocity coefficient being raised from 89·5 to about 93·2 per cent. over the practical range of this type of nozzle. The throat was then reduced to 0/1 and tested, the results being plotted in Curve 23.

Unlike the 12-deg. thin-plate nozzle, a steady curve was obtained, all the points of which fall within the shaded band of accuracy. It is possible, however, that this may be due, in part, to the fact that the distance from the centre of the exit face of this 0/1

Fig. 4. IMPULSE NOZZLE—BOX. NOZZLE 2 INCHES HIGH. ANGLE 12°. PLATES 3/16 INCH.

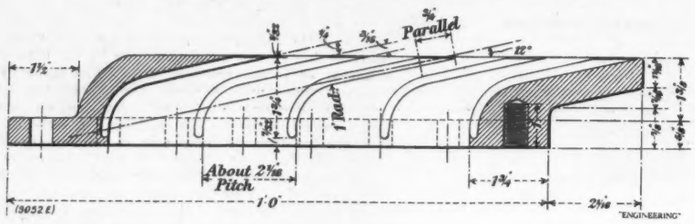


Fig. 6. DETAILS OF "CHAMFERS" FOR 12° THICK PLATE IMPULSE NOZZLES.

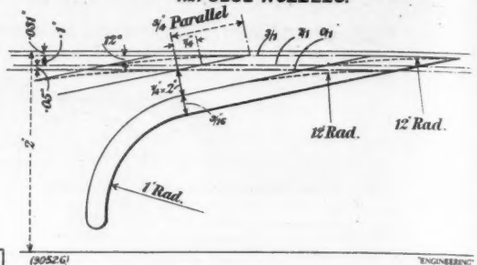


Fig. 5. IMPULSE NOZZLE. 12° NOMINAL ANGLE. PLATES 3/16" THICK.

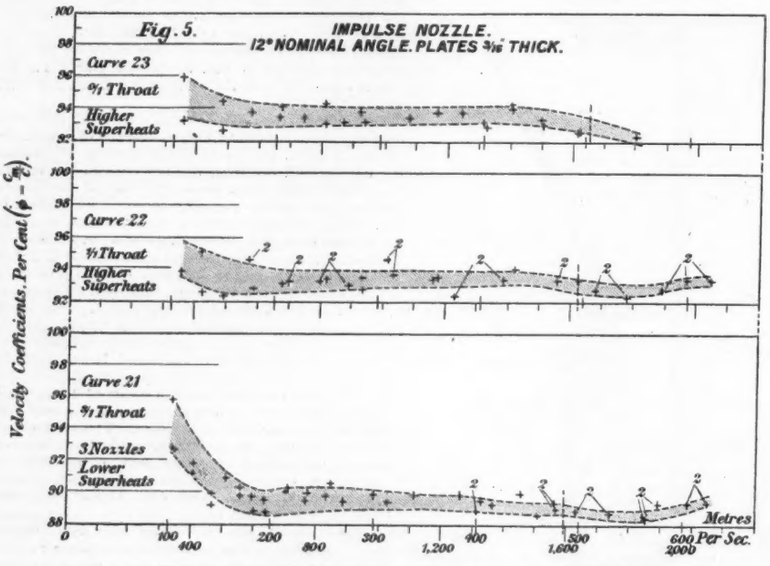


Fig. 9. BUILT-UP TYPE OF IMPULSE NOZZLE. 13½° NOMINAL ANGLE.

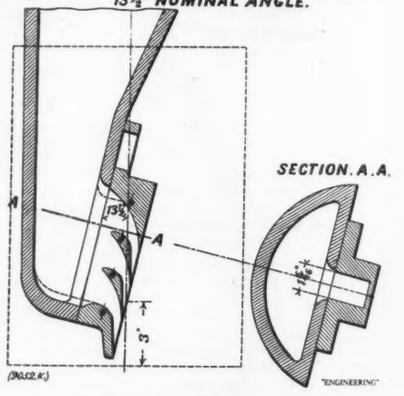


Fig. 7. IMPULSE NOZZLE. 12° NOMINAL ANGLE. PLATES 3/16" THICK. WITH CHAMFERED EXIT.

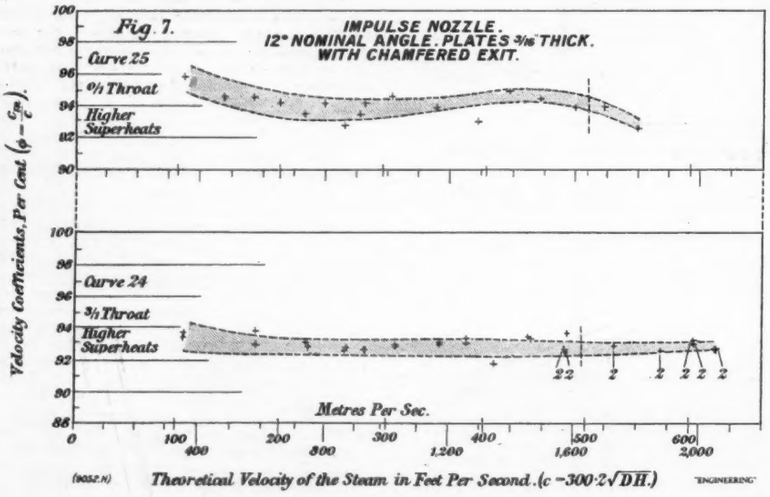
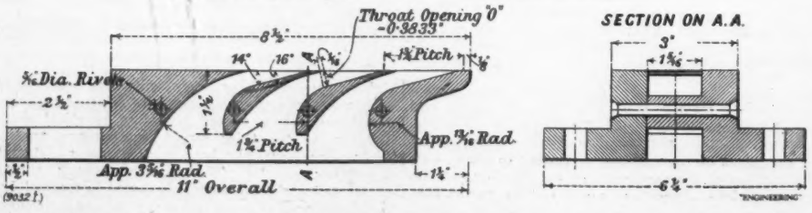


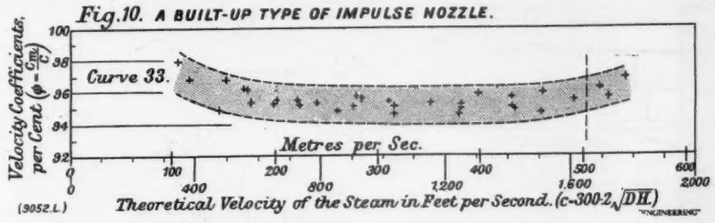
Fig. 8. DETAIL OF BUILT-UP TYPE OF IMPULSE NOZZLES.



nozzle was 4¼ in., as compared with 3¼ in. in the case of the 12-deg. thin-plate nozzle. A slight further increase in the velocity coefficient is also indicated. No two-nozzle tests were taken on one 0/1 throat.

Two series of tests were taken on this nozzle-box with a 12-in. radius chamfer worked on the back edges of the partition plates. Details of this chamfering, as well as the curtailment of the throat for the non-chamfered tests, may be seen in Fig. 6. Tests on the 3/1 throat condition are given in Fig. 7 (Curve 24). Good steady test conditions were obtained and the velocity coefficient at medium velocities was lifted from 89·4 to 92·8 per cent. when compared with the non-chamfered 3/1 thick-plate nozzle. The result is

Fig.10. A BUILT-UP TYPE OF IMPULSE NOZZLE.



very similar to the 20-deg. thin impulse nozzle (Curve 1, Second Report), with a corresponding throat ratio.

Chamfered tests were also taken after the throat ratio had been reduced to 0/1. Details of these tests will be found plotted in Fig. 7 (Curve 25). Further improvement is shown at medium velocities. The velocity coefficient reaching 94 per cent. at 1,000 ft. per second and 94·4 per cent. at 1,200 ft. per second. Here, again, the result is comparable with the 20-deg. thin-plate nozzle with a 0/1 throat ratio (Curve 4, Second Report).

Built-up Type of Impulse Nozzle.—One result of the London discussion on the Third Report has been that Mr. B. Pochobradsky has kindly supplied the committee with a nozzle-box embodying the design of a built-up impulse type of nozzle. A drawing of this nozzle is given in Fig. 8. The "nominal" angle $\left(\sin^{-1}\frac{o}{q}\right)$ of this nozzle is 13½ deg., the "reference" angle $\left(\sin^{-1}\frac{o}{p}\right)$ is given in the accompanying table of dimensions.

No. 1 nozzle was the top one as set in the tester. It will be noted that this nozzle has the same total discharge area as the committee's nozzles, but that the ratio of opening to height is different. In the committee's impulse nozzles the throat opening was ¼ in. and the height 2 in. The construction of the nozzle is also different. Instead of cast-in partition plates left in the rough, this nozzle was machined all over and had partitions of varying thickness, more like a Parsons reaction nozzle with an impulse type of exit. There is practically no length of throat, however, beyond the opening, the total amount of overlap being $\frac{1}{16}$-in. for a throat opening of just over ⅜-in.

Nozzle No.	Throat opening o (inches).	Nozzle height h (inches).	Pitch p (inches).	$\frac{o}{p}$	Geom. angle $\sin^{-1}\frac{o}{p}$	Throat area (at exit) a (sq. in.)
1	0·3853	1·311	1·737	0·2218	12° 49′	0·5051
2	0·3873	1·322	1·752	0·2211	12° 47′	0·5120
3	0·3843	1·316	1·716	0·2240	12° 56′	0·5057

Total throat area = 1·523.

The setting of this nozzle in the tester is shown in Fig. 9. It will be noted that the lower half of the nozzle pipe has been enlarged as compared with the other tests, and that the steam supply, instead of entering the nozzle more or less at right angles, as in the case of the nozzles already tested by the committee, is allowed to sweep in gradually at either end. This was done in order to improve, if possible, the conditions of entry of the steam. The rake of the nozzle prevented the standard distance to the pad of 2½ in. from being used. In this case it had to be 3 in. as shown. The angle of setting (13½ deg.) was determined from the efflux tests. These are described later, but it may be mentioned here that this nozzle gave considerable variation in the angle of efflux for different pressure ratios up to the critical pressure. The results of some thirty tests on this nozzle are plotted in Fig. 10. At the lower velocities the steam conditions were quite steady, and reliable test readings could be obtained, but beyond 1,000 ft. per second increasing unsteadiness of the jet was found, with the consequence that the lever balancing the thrust on the cage-plate could only be held approximately steady by the control of the steam inlet valve. This instability on the exhaust side of the nozzle was communicated to the inside of the nozzle pipe, with the result that the pressure readings, taken on a mercury column, cannot be considered to be so accurate as in the case of former tests. Throughout the length of the curve the degree of accuracy never became less than ± 1 per cent. of the velocity coefficient. The pulsations of the lever had no definite period.

It will be noted that the mean efficiency of this nozzle obtained at medium velocities lies some 1 per cent. above the best values obtained with the test nozzles of the committee. The nozzle differs, however, from the other nozzles in having a better surface and in turning the steam supply less at entry. This latter condition could not be reproduced in a continuous nozzle, where the entry would have to be made equivalent to the dotted lines shown on Fig. 9.

(To be continued.)

NOTE ON NITROGEN AS A POSSIBLE FACTOR IN TEMPER BRITTLENESS.*

(Communication from Research Department, Woolwich.)

By W. T. GRIFFITHS, M.Sc., F.I.C.

IT has been pointed out by certain investigators that in a steel which exhibits susceptibility to temper-brittleness, different magnetic properties may be associated with the high and the low notched-bar impact figures shown by the steel after quick and slow cooling from the tempering temperature. While considering the possibility of using the rate of change of some magnetic property with change of temperature as an indication of the position of the so-called "embrittling range" in temper-brittle steels, the author was struck by the fact that steels containing nitrogen were said to show magnetic changes at a somewhat similar temperature to those stated to mark the beginning and end of this range.

Further investigation showed that after increasing the nitrogen content in certain steels which were non-susceptible to temper-brittleness, an effect could be produced on the impact figure of the steel by quickly or slowly cooling from 630 deg. C. to 650 deg. C., which was apparently identical with that characteristic of temper-brittle steels. A carbon steel of the composition :—

Carbon	Silicon	Manganese	Sulphur	Phosphorus	Nitrogen
p.c. 0·39	p.c. 0·093	p.c. 0·57	p.c. 0·020	p.c. 0·025	p.c. 0·004

and non-susceptible to temper-brittleness was used for the first experiments. After hardening from 900 deg. C. and tempering at 650 deg. C., specimens quickly and slowly cooled gave impact figures of 52 and 50 respectively.

(*a*) A piece of the steel, 4½ in. by 1 in. by ½ in., was quenched in water from 900 deg. C. and then heated in a wire-wound tube furnace at 600 deg. C. for five hours, dry ammonia being passed over it. The specimen was divided into two pieces, each 4½ in. by ½ in. by ½ in., which were heated in air in a muffle furnace at 650 deg. C. for two hours; one piece was then quenched in water, and the other cooled in the furnace at a rate of 0·3 deg. C. per minute. Both specimens were machined to standard 10 mm. by 10 mm. Izod test pieces. The highly nitrified skin was removed in the course of machining, and the notches were cut on the face which had not been exposed to the ammonia. Thus the test piece contained only the small amount of nitrogen which had diffused inwards. (Average nitrogen content now 0·015 per cent.) The average Izod impact figures were :—

After water cooling from 650 deg. C. .... 35 ft.-lb.
After slowly cooling from 650 deg. C. .... 20 „

(*b*) A similar specimen of the same steel was heated in ammonia for 30 hours at 630 deg. C. It was divided longitudinally as before, and the pieces were hardened by heating in air at 900 deg. C. for one hour and quenching in water. They were then tempered at 650 deg. C., cooled and machined as described above. The average Izod impact figures were :—

After water cooling from 650 deg. C. .... 30 ft.-lb.
After slowly cooling from 650 deg. C. .... 12 „

The Brinell hardness of both test pieces was 173.

(*c*) Another specimen was given a similar treatment to the last, but with nitrogen replacing the ammonia, thus avoiding oxidation but introducing no nitrogen into the steel. Identical impact figures (63 ft.-lb.) were obtained after final water cooling and slow cooling, showing that the differences previously obtained were not due merely to the prolonged heating at 630 deg. C. before quenching and tempering.

(*d*) A non-susceptible nickel steel of the composition

Carbon	Silicon	Manganese	Sulphur	Phosphorus	Nickel	Nitrogen
p.c. 0·31	p.c. 0·06	p.c. 0·17	p.c. 0·024	p.c. 0·023	p.c. 3·67	p.c. 0·006

was heated first to 850 deg. C. for one hour in an atmosphere of nitrogen, and was then cooled rapidly in the furnace to 710 deg. C. The nitrogen was replaced by ammonia and the steel held at 700 deg. to 710 deg. C. for 48 hours in a stream of this gas. After cooling in the furnace to room temperature, specimens cut for further treatment were oil-hardened from 900 deg. C., tempered at 630 deg. C. for two hours, one being cooled in water and the other slowly cooled at 0·3 deg. C. per minute. The average Izod impact figures and Brinell hardness numbers were :—

After water-cooling from 630 deg. C. 81 ft.-lb. and 193.
After slowly cooling from 630 deg. C. 49 ft.-lb. and 188.

Specimens of the same steel into which no nitrogen had been introduced, after oil-hardening from 900 deg. C. and tempering, gave Izod impact figures :

After water-cooling from 630 deg. C. 75 ft.-lb.
After slowly cooling from 630 deg. C. 74 „

The fractures of all specimens containing nitrogen water-cooled after tempering were fibrous, but those of the slowly-cooled test-pieces were of the usual bright granular type of temper-brittle material. No differences were observed in the microstructure of test pieces giving the higher and lower impact figures, and it will be seen that the Brinell hardness numbers of the two are similar.

These results may be accounted for if, as indicated by several investigators, the nitride phases, free at room temperatures, pass into solution on heating to temperatures above 600 deg. C. and are retained in solution on water-cooling from those temperatures, though they separate again on slow cooling. Referring to the needles of "nitride" present in nitrified steels, Dr. A. Fry states that "on quenching from temperatures above 450 deg. C. the needles decrease and go on lessening as the temperature from which quenching is carried out is raised; when a temperature of 580 deg. is reached the nitride needles remain entirely in solution."

These temperatures, it will be noticed, are in substantial agreement with those marking the beginning and the end of the embrittling range, and if the nitride phases are in equilibrium with each other at each temperature, properties such as those exhibited by steels susceptible to temper-brittleness may be expected in steels water-cooled from temperatures between and above those mentioned.

Attempts to introduce nitrogen into alloy steels other than the nickel steel mentioned above have, up to the present, been unsuccessful. The rate of diffusion of nitrogen into these steels at any temperature suitable for nitrification with ammonia is extremely slow—hard, highly nitrified surface layers forming without the centre of the specimen being affected.

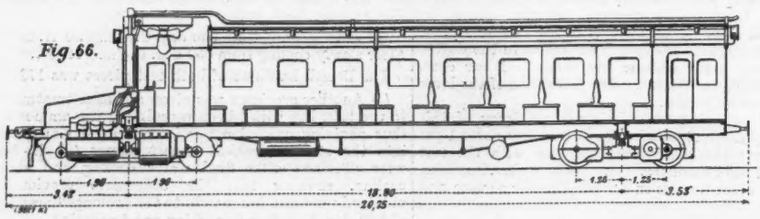
It however appears from what has been done that nitrogen may in certain circumstances exert an important influence on the susceptibility of a steel to temper-brittleness.

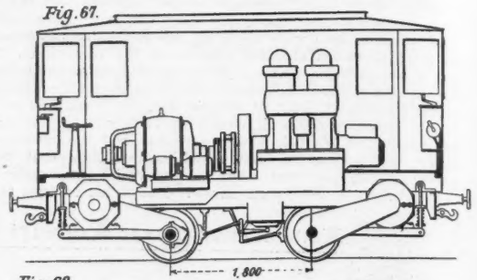
It has been stated that, when phosphorus and manganese contents are low, differences in susceptibility, apparently unconnected with chemical composition, but more probably depending on the method of manufacture, are sometimes found. The unknown factor in these instances may possibly be nitrogen content, which is known to vary not only with method of manufacture, but also by reason of additions made to the steel. Tschischewski has shown that nitrogen may be introduced in combination with manganese, silicon, or aluminium, which are employed in different relative quantities in different steel-making processes.

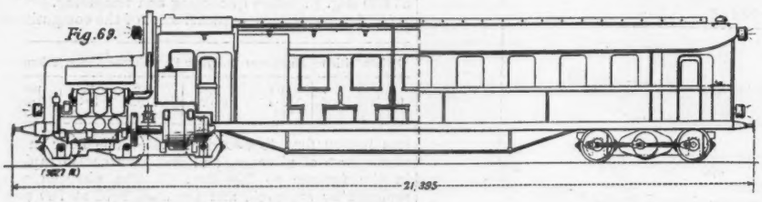
To determine the possible influence of nitrogen on susceptibility to temper-brittleness, or to elucidate the analogous effect revealed by the results described above, will require much further investigation. These experimental observations are, however, brought before the Institute at this stage, as they are thought

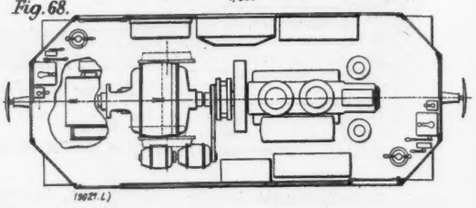
* Paper read before the Iron and Steel Institute, London, on Friday, May 8, 1925. Abridged.

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.









to be of interest in connection with the question of the effect of composition on the susceptibility of steel to temper-brittleness, a subject which is being dealt with in another paper presented at this meeting.

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.*

By M. EUGENE BRILLIÉ.

(*Continued from page* 560.)

Electric Transmissions.—The installation on a vehicle having electric transmission generally comprises a continuous-current generator driven by the engine, and electric motors driving the axles; there are either one or two driver's compartments fitted with controllers. Electric transmission gives a continuously variable gear, and allows the vehicle to adapt itself to the best advantage at every moment to the speed of the engine and that of the vehicle itself. It makes driving extremely easy, and lends itself readily to the arrangement of two control compartments.

In the Crochat system the generator is both shunt and series wound; the generator is excited on starting by the series winding, which is put progressively into circuit. The variations in power are obtained by speeding up the engine by an accelerator as on ordinary automobiles. The system has been applied on various types of locomotives using explosion motors, and weighing from 3 to 40 tons, and it has also been applied to rail motor vehicles.

A method more generally used is the following: A shunt-wound generator or an independently excited generator is used, giving variable and adjustable voltage; the electric motors may be either shunt or merely series wound, and they may be coupled in series or in parallel according to the running conditions.

Vehicles having electric transmission are generally fitted with the dead-man switch, in which the driver must keep a knob depressed by his hand, and, should he release it, the motor is cut out, the brakes being automatically applied after a few seconds.

About 1910, the Prussian railways, particularly in the neighbourhood of Posen, put several rail motor vehicles driven with benzol into service on light railways (Fig. 66). In these, the generator set is carried on the front bogie; the motor is arranged under a bonnet in front of the body, an arrangement which makes the motor easily accessible, and in case of repair allows the bogie carrying the motor to be removed from the rest of the vehicle. These vehicles are fitted with a six-cylinder Deutz V-type engine of 100 to 150 h.p., running at 700 to 1,100 r.p.m.; the electric generator is shunt wound, giving 65 kw. at 300 volts when running at 700 r.p.m.; the power is regulated by the exciting current. Electric motors of the traction-type drive direct on to the axles of the rear bogie.

Mr. Mallez, Director of the Ain Tramways, has constructed a locomotive with electric transmission fitted with a Ballot semi-Diesel two-cylinder engine of 60 h.p., running at 400 r.p.m.; the drive is effected by two traction-type series motors, driving the axles by chains, the reason for the arrangement being that a wagon underframe was used the diameter of the wheels of which did not permit of the adoption of a pinion drive. The weight of the locomotive in running order is 15 tons, and it can haul 40 tons on the level at 25 miles per hour. The machine is illustrated in Figs 67 and 68.

The Sulzer rail motor vehicles are arranged similarly to those of the Prussian railways, with the generating set on the front bogie,* as shown in Figs. 69 and 70, an independent view of the bogie with its generator being given in Fig. 71.

The motor is a Sulzer Diesel two-cycle, six-cylinder unit, of 200 h.p. at 440 r.p.m.; it drives a shunt-wound dynamo with voltage regulated by exciting current from + 300 to — 300 volts on the Ward-Leonard system. The motors are series wound, carried on the rear bogie; they drive a dummy axle which drives the wheels by coupling rods (in later models, traction motors are used, driving the axles direct). The engine is started by the generator by means of accumulator batteries. A dead-man switch is fitted in each driver's cab. These rail motor vehicles are designed to carry 100 passengers. The weight is 64 tons, of which 26 tons are on the leading bogie. The speed on the

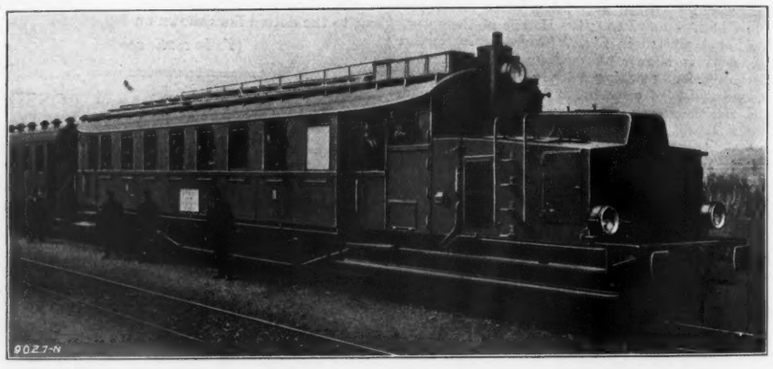


FIG. 70. SULZER RAIL MOTOR WITH ELECTRIC TRANSMISSION.

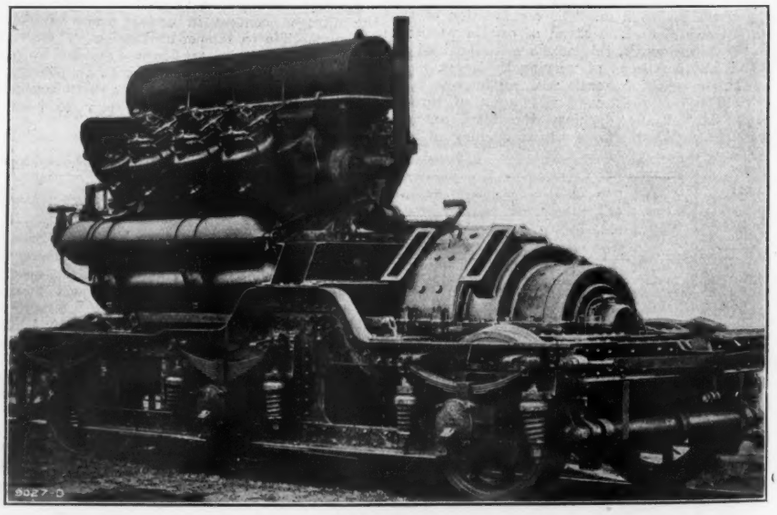


FIG. 71. ENGINE AND GENERATOR ON BOGIE OF SULZER RAIL MOTOR.

* Paper read before the British Section of the Société des Ingénieurs Civils de France on April 1, 1925. Abridged.

* Le Génie Civil of December 30, 1922.

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.

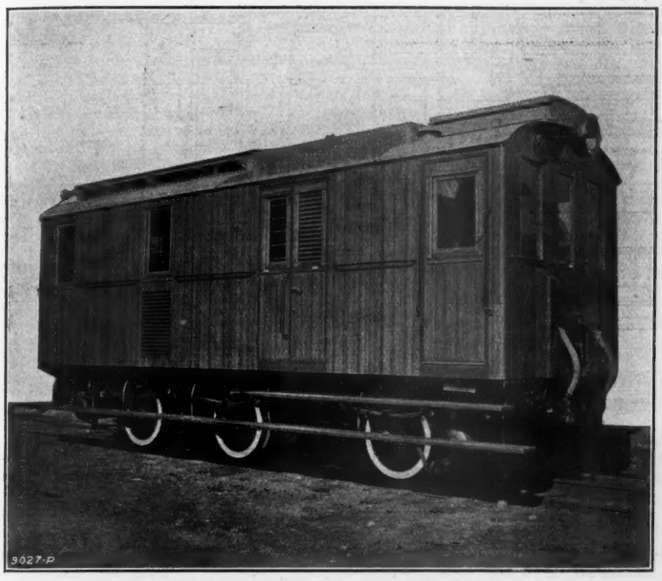


FIG. 72. 75 H.P. POLAR-DEVA LOCOMOTIVE.

FIG. 73. INTERIOR OF 75 H.P. POLAR-DEVA LOCOMOTIVE.

Fig. 74.

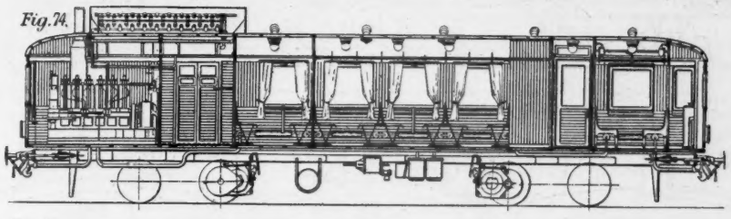


Fig. 75.

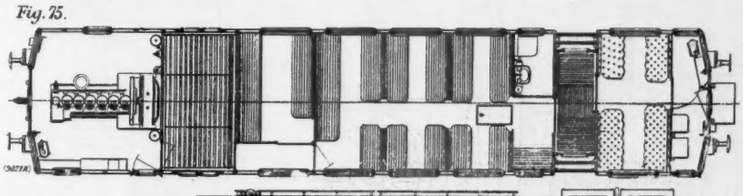


Fig. 77.

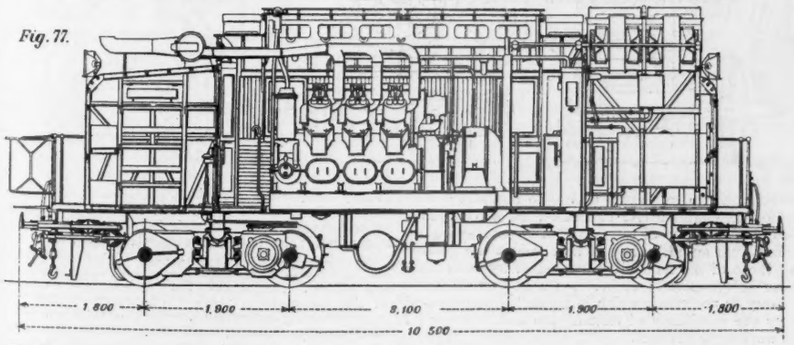
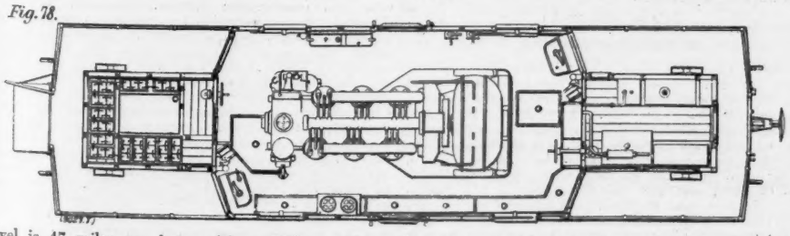


Fig. 78.



level is 47 miles per hour with a trailer weighing 30 tons. These vehicles run from Zurich to Romanshorn on a line having gradients of 1 in 80, and haul two trailers weighing 25 tons each. The consumption of fuel is given as 2·9 lb. to 3·2 lb. per 100 ton-miles.

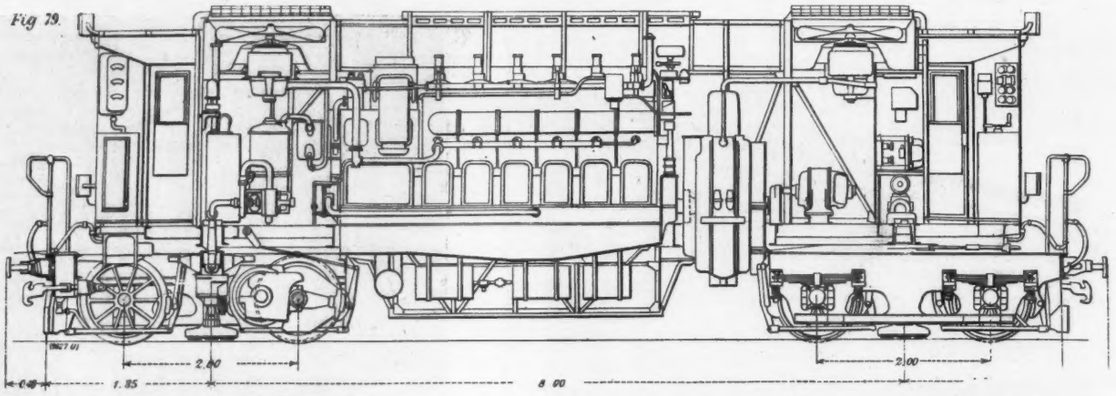
The Polar-Deva vehicles are constructed in Sweden by the Diesel Elektriska Vagn Aktiebolaget of Vasteras.

FIG. 76. INTERIOR OF 250 H.P. POLAR-DEVA LOCOMOTIVE.

The motors are four-cycle, of Polar-Diesel type, running at 550 r.p.m. The generator is direct coupled to the motor of the eight-pole type, shunt wound, and the voltage is regulated by exciting up to 550 volts. An accumulator battery allows the engine to be started by the generator. The electric motors are of the series-wound traction-type. A number of types have been worked out with motors of 75 h.p., 120 h.p., 160 h.p. and 258 h.p. for metric gauge and also for normal gauge. The Swedish companies using these vehicles give the consumption of fuel as 2·7 lb. to 3·6 lb. of oil per 100 ton-miles according to the gradients on the line. The economy as compared with steam for the same tonnage is from 50 to 60 per cent., according to information given by the directors of the two companies. Exterior and interior views of one of the 75-h.p. machines are given in Figs. 72 and 73, while the 120-h.p., 33-ton vehicle is shown in Figs. 74 and 75, and an interior view of the 250-h.p., 50-ton vehicle in Fig. 76. A Polar locomotive of 100 h.p. to 150 h.p. has been running since January, 1923, on the Tunisian Railways between Tunis and Hamman-Lif. The weight of this locomotive is about 30 tons, and it uses 2·8 lb. to 3·2 lb. of fuel per 100 ton-miles, including the locomotive. It is shown in Figs. 77 and 78. The results of working show an economy of

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.

Fig 79.



50 per cent. fuel, and also in the staff for the same tonnage as compared with steam.

The Fiat works in Turin, working in conjunction with Brown, Boveri & Co., have constructed a locomotive of 440 h.p. and 3-ft. gauge for the Colobro-Lucano Railway, which has gradients up to 6 per cent. and curves of 110 yards radius. This locomotive (Fig. 79) has two bogies and drives on all wheels; it is capable of supplying current to a special trailer having two driving axles. The engine is a six-cylinder, two-cycle Diesel, running at 500 r.p.m. It is started electrically by means of an accumulator battery. Two radiators are arranged in the upper portion with electrically driven fans. The electric installation comprises a 275-kw. generator at 300 to 500 volts, variable by the exciting current. The exciting generator running at 200 r.p.m., develops 20 kw. at 120 volts. It supplies, besides the exciting current for the generator, the power required for the auxiliary circuits (compressor, pump, and fans) and for the battery. The traction motors are series wound with six main and six auxiliary poles; they are capable of giving continuously 54 kw. at 410 volts and 800 r.p.m. They drive the axles by gears with a reduction of 1 to 5·3. The brakes are of very special construction on account of the steepness of the gradients; apart from the hand brake and the Westinghouse brake, a special safety brake of the trunk system with carborundum shoes is fitted. The locomotive weighs 46·5 tons. The normal weight of the train is 105 tons, including the special trailer; a speed is obtained of 10 m.p.h. up grades of 5 per cent., and 8 m.p.h. up grades of 6 per cent.

Professor Lomonossof, on behalf of the Russian Government, has had constructed, by the Hohenzollern A.G. of Dusseldorf, a Diesel-electric locomotive of 1,200 h.p., having details as follows:—The locomotive has five driving axles and two Bissel bogies; the engine is a Diesel M.A.N. submarine type, four-cycle, six-cylinder unit, with compressed-air injection; the dimensions are: bore 450 mm., stroke 420 mm., power 1,200 h.p. at 450 r.p.m., starting by compressed air. It drives, through an elastic coupling, an electric 12-pole generator, giving 800 kw. at 600 to 1,100 volts. The electric motors are of the series type, self-ventilated, with four poles, and of 142 kw.; they drive the wheels through gearing with a reduction ratio of 1 to 6·13. The weight of the motor with its casing is 4 tons. The exciter carried on the end of the generator shaft is excited by an auxiliary dynamo which itself is excited by an accumulator battery. The driving shaft is prolonged to drive the fans by gearing; the fans are placed below the radiators. The radiators can only ensure the cooling of the water in the cold season; in summer, a double-bogie tender is attached to the locomotive, carrying auxiliary radiators with fans driven by a special Diesel motor. The machine is illustrated in Figs. 80 to 83.

This locomotive has been tested in the shops on a special test bed fitted with brake rollers under each driving axle. These trials formed the subject of a paper published in German by Professor Lomonossof, giving the results obtained, the faults discovered, and the modifications that were made in the final scheme.* The weight of the locomotive empty is 113 tons; in running order 120 tons. The adhesive weight is 95 tons. If the tender is taken to weigh 50 tons, the total would amount to 170 tons for a power of 900 h.p. delivered at the periphery of the wheels.

Electric transmission is a solution well suited to railway work up to powers of 700 to 800 h.p.; it is easy for the engine-driver to handle, has a continuous range of speeds, and of tractive effort from starting-up to maximum speed. Its cost and weight are greater than those of mechanical transmission, for such sizes as can be compared; it involves a loss of efficiency of about 30 per cent., which is partially compensated for by the possibility of running the motor under its best working conditions.

(To be continued.)

* As originally schemed the locomotive was fitted with radiation of insufficient size at each end; the exciter was driven by a semi-Diesel 20-h.p. engine, which did not prove satisfactory.

Fig. 80.

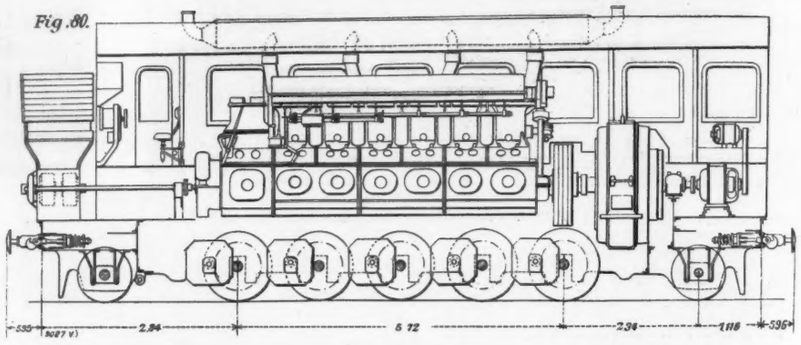


Fig. 81.

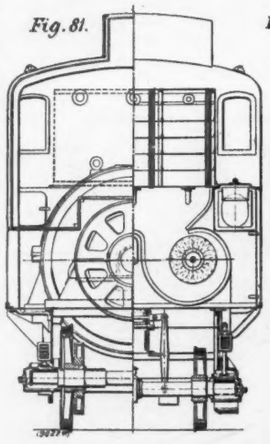


Fig. 82.

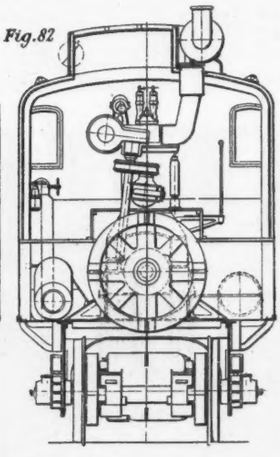
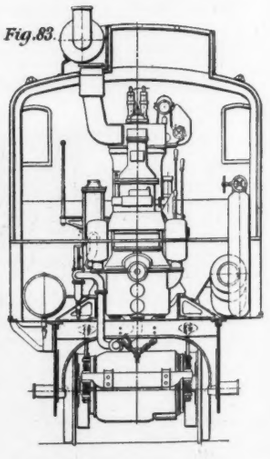


Fig. 83.



PETROL FROM NATURAL GAS IN 1923.—In a report issued by the United States Geological Survey at Washington some information on the petrol industry is given for the year 1923. A total of 816,226,000 gallons of unblended natural gas petrol, having a value at the plants of 77,268,000 dols., was produced in the United States in that year. This output, an increase of 61 per cent. over that of 1922, was more than double that of 1920, and the year's increase of 310 million gallons is more than the total production of the country in 1918. Notwithstanding an increase of 22 per cent. in the quantity of petrol produced from petroleum in 1923, the quantity produced from natural gas was equivalent to approximately 11 per cent. of the quantity produced from petroleum, as compared with 8 per cent. in 1922. The rank of the four leading States—Oklahoma, Texas, California and West Virginia—remained the same as in 1921 and 1922. An increased supply of natural gas petrol in California followed the development of the new fields in the Los Angeles Basin, from which great quantities of natural gas were produced with the petroleum, but only a fraction of the gas available was utilised. During 1923 the number of plants working on the compression method of extracting the petrol from natural gas decreased, while the number using the oil absorption process, both singly and in combination with the compression system, increased. The new charcoal process, in which natural gas is brought into intimate contact with charcoal in the capillaries of which the vapours are condensed, was reported in use by 10 plants. The increased average capacity of the plants now in operation is emphasised by the fact that though in 1918 and 1923 the plants numbered about the same, the output in the latter year was nearly three times that in the former year. The quantity of natural gas treated in the recovery of natural gas petrol in 1923 was equivalent to 87 per cent. of the total quantity of natural gas consumed in the United States as contrasted with 71 per cent. in 1922, 54 per cent. in 1917 and 2 per cent. in 1913. These figures not only show the growth of the industry from another viewpoint and the increasing conservation of natural gas, but they indicate the near approach of the time when the available annual supply of the gas which hitherto has been much in excess of the quantity treated for the extraction of gasoline, will be a controlling factor in the growth of the industry.

TEMPER-BRITTLENESS OF STEEL.

*Temper-Brittleness of Steel; Susceptibility to Temper-Brittleness in Relation to Chemical Composition.**

(Communication from the Research Department, Woolwich.)

By R. H. GREAVES and J. A. JONES.

Susceptibility to Temper-Brittleness.—The susceptibility of a steel to temper-brittleness is measured by the ratio of the impact figure of a sample rapidly cooled after tempering to that of a sample slowly cooled, the previous history being the same in each case. The following procedure was adopted as the standard test for susceptibility. Two similar samples of the steel were taken, oil-hardened from 900 deg. C. and tempered for two hours at 650 deg. C. One sample was cooled in water after tempering, and the other cooled slowly, the rate of cooling between 600 deg. and 400 deg. C. being uniform and 0·3 deg. C. per minute. The ratio of the impact figures of these samples was taken as expressing susceptibility under standard conditions. If 650 deg. C. too nearly approached the critical range of the steel, a slightly lower tempering temperature was employed.

The Embrittling Range of Temperature.—The transformation of nickel-chromium steels from the tough to the brittle condition in the vicinity of 550 deg. C. occurs, not at a definite temperature, but over a range of temperatures within which there appears to be equilibrium between the condition producing toughness and the condition producing brittleness. If two samples of the same hardened and tempered steel, one initially in the tough and the other in the brittle condition, be heated to any temperature within the range for a sufficient time and then quenched in water, they attain to the same impact figure. The behaviour of a typical susceptible steel is illustrated in Figs. 1 and 2.

The difference in the rate of attaining the equilibrium impact figure at a given temperature is not very great for different steels, but the rate diminishes very rapidly with fall of temperature. Hence a steel with a high embrittling range has a far better opportunity of continuing in equilibrium during any process of slow cooling, and so of attaining a low impact figure. Differences of 30 deg. or 40 deg. C. in the position of the upper limit of the range were observed in steels of the same type, the higher ranges being associated with greater susceptibility to temper-brittleness. The highest and lowest ranges observed in the commercial steels examined are shown in Fig. 3.

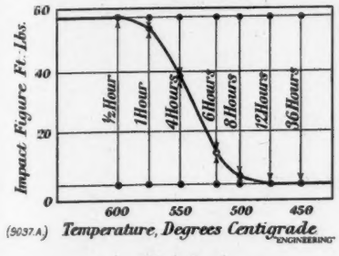


FIG. 1.

Embrittling range, and time taken to attain the equilibrium impact figure, in the acid open-hearth nickel-chromium steel of the following composition:—

C.	Si.	Mn.	S.	P.	Ni.	Cr.
0·26	0·07	0·66	0·020	0·026	3·53	0·84

Oil-hardened from 1,000° C. and tempered at 650° C.

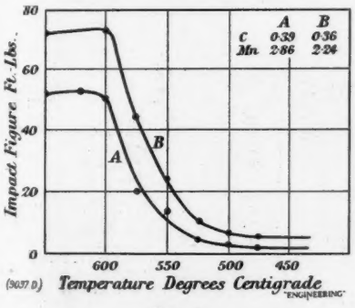


FIG. 4.

Embrittling range of carbon steels with high manganese content.

THE INFLUENCE OF CHEMICAL COMPOSITION ON SUSCEPTIBILITY.

Material Used and Experimental Details.—All the steels used in the work now described were (except where otherwise stated) crucible steels, and each series was made from the same raw materials under identical conditions. Ingots weighing about 100 lb. were rolled into bar 1½ in. by ¾ in. in section, from which specimens were cut for heat-treatment in the laboratory. The conditions under which heat-treatment and mechanical tests were carried out were identical with those described in the previous paper.* No reference is here made to the conditions of treatment which yield the best combination of properties for each steel; and the steels are not compared on the basis of their general mechanical properties, but solely on their susceptibility to temper-brittleness.

The following limits generally apply throughout, except in steels in which the element in question was purposely introduced in larger quantities: Manganese, 0·25 per cent.; silicon, 0·15 per cent.; sulphur, 0·04 per cent.; and phosphorus, 0·03 per cent.

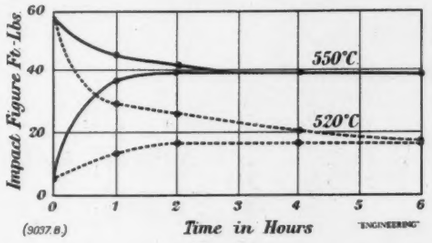


FIG. 2.

Rate of change of impact figure of tough and brittle specimens heated at different temperatures within the embrittling range and quenched in water.

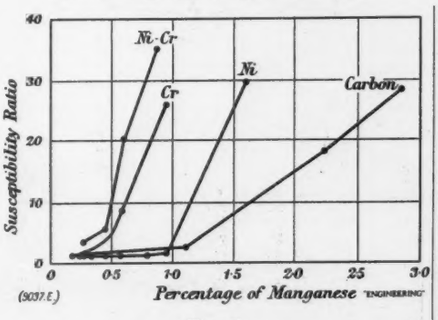


FIG. 5.

Relation between susceptibility and manganese content.

The Effect of Manganese.—Carbon steels with low manganese and phosphorus are only very slightly (if at all) susceptible to temper-brittleness, but increase in manganese content leads to increased susceptibility. The susceptibility of steels with over 2 per cent. of manganese is very marked, but good impact figures can be obtained by suitable treatment.

The position of the range of temperature within which the steels develop temper-brittleness, and the times required for tough and brittle material to arrive at the same condition as regards impact figure, when heated within the range, have been determined for steels A and B. (Fig. 4). A supply of tough and brittle material having been obtained from both steels, specimens were reheated at temperatures between 475 deg. C. and 620 deg. C. for various times. At the end of the required time the specimens were withdrawn, cooled in water, and tested: the results are shown in Fig. 4. The position of the ranges (600 deg. to 475 deg. C. and 610 deg. to 475 deg. C. for the steels with 2·24 and 2·86 per cent. of manganese respectively) was within the limits observed for commercial nickel-chromium steels.

The results of varying the manganese content in chromium, nickel, and nickel-chromium steels are shown in Fig. 5. After a certain percentage is exceeded an increase in manganese content has a marked influence on susceptibility. This influence is evident at a lower manganese content in the steels containing chromium than in nickel or carbon steels.

The Effect of Phosphorus.—The importance of the influence of phosphorus on susceptibility to temper-brittleness has been pointed out by Dr. J. H. Andrew and Mr. G. W. Green, who carried out tests on a series of 3·5 per cent. nickel steels, containing 0·35 per cent. of carbon, 0·45 per cent. of manganese, and from 0·018 per cent. to 0·152 per cent. of phosphorus, oil-hardened from 850 deg. C. and tempered for three hours at 650 deg. C., after which they were either quenched in water or slowly cooled in the furnace, reaching room temperature in two and a half hours.

Their results indicate that the susceptibility of a nickel steel to temper-brittleness is dependent on phosphorus content, and they were supported by further results on nickel-chromium steels containing 0·01 per cent. to 0·058 per cent. of phosphorus, taken from actual practice, details of which have, however, not been published. As has already been mentioned, the authors are of the opinion that their own work shows no indication that phosphorus (up to 0·04 per cent.) has a predominating influence in determining the susceptibility of good alloy steels, subject to the ordinary variations of chemical composition. The phosphorus present will doubtless have some effect, but its influence may be entirely masked by that of other variables.

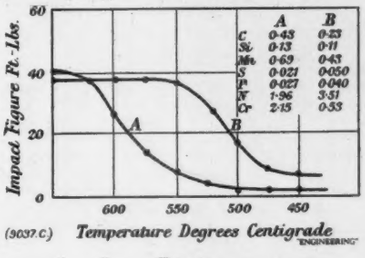


FIG. 3.

Highest and lowest embrittling ranges observed in commercial steels.

Abnormally high phosphorus content, on the other hand, like abnormally high manganese content, has a marked influence on susceptibility. The results obtained from nickel steels containing 0·33 per cent. carbon, 3·6 per cent. nickel and high phosphorus, and also from nickel-chrome steels containing 0·30 per cent. carbon, 3·6 per cent. nickel, 0·7 per cent. chromium and high phosphorus are illustrated in Fig. 6. Dr. Andrew's results are plotted in the same diagram, but in comparing them with those now obtained it must be noted that though the rate of slow cooling he employed was quicker, the manganese content of his steels was higher. The impact figures reached by tough and brittle specimens of the same high-phosphorus nickel and nickel-chromium steels, heated together at temperatures within the embrittling range and cooled in water, are shown in Fig. 7.

The Combined Effect of Phosphorus and Manganese.—High manganese and high phosphorus each give rise to increased susceptibility to temper-brittleness, and when both elements are present in abnormal amount each intensifies the action of the other.

The Effect of Silicon.—The only high-silicon nickel steel examined gave an indication that silicon tends to increase susceptibility to temper-brittleness, but not to an important extent, in steels within the ordinary limits of variation of silicon content. A high-silicon carbon steel showed about the same susceptibility as might be expected from a similar steel with equal manganese content and low silicon. In silicon-manganese steels the silicon is unlikely to reduce, and will probably reinforce, the effect of the manganese in inducing susceptibility.

The Effect of Vanadium.—A number of chromium, nickel, and nickel-chromium steels containing vanadium have been examined. In the series of crucible steels investigated the influence of vanadium on the susceptibility to temper-brittleness was slight. The results obtained show a small and unimportant increase in susceptibility when vanadium is present. They definitely indicate, however, that vanadium shows no tendency to reduce susceptibility or to render steels non-susceptible to temper-brittleness. This conclusion is confirmed by the fact that some samples of acid open-hearth nickel-chromium-vanadium steels are among the most susceptible of the steels examined, while chromium-vanadium steels are well known to show temper brittleness.

The Effect of Tungsten.—Similar information has been obtained in the course of work carried out on 22 carbon, nickel and nickel-chromium steels covering a similar range of composition, but containing, instead of vanadium, tungsten up to 2·4 per cent. in nickel steels, and up to 1·7 per cent. in carbon and in nickel-chromium steels. The presence of tungsten caused no appreciable change in the susceptibility.

* Paper read before the Iron and Steel Institute, London, on Friday, May 8, 1925. Abridged.

* Journal of the Iron and Steel Institute, 1920 No. II, page 171.

Non-susceptible carbon and nickel steels remained non-susceptible, slightly susceptible nickel-chromium steels remained susceptible to about the same degree.

Only one electric furnace nickel-tungsten steel has been examined. This contained :—

C.	Si.	Mn.	S.	P.	Ni.	W.
0·43	0·27	0·40	0·009	0·025	2·97	2·00

and showed a susceptibility of 1·1, the corresponding ratio after hardening from 1,000 deg. C. being 1·3. No acid open-hearth steel containing tungsten has been examined.

The Effect of Molybdenum.—The addition of molybdenum exercises a very powerful influence in reducing, or in some cases apparently eliminating, susceptibility to temper-brittleness. The ratio 0·97 to 1·06 which acid open-hearth steels containing molybdenum consistently show is in marked contrast to the values shown by other acid open-hearth alloy steels not containing molybdenum. These steels, judged by the results of the standard treatment, are non-susceptible.

The effect of molybdenum has been studied in a series of 23 crucible steels consisting of carbon, nickel, chromium and nickel-chromium steels alloyed with

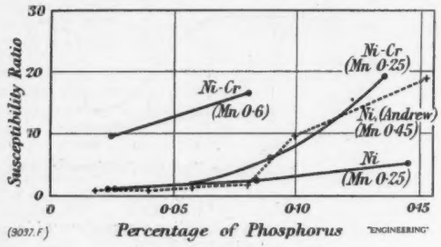


FIG. 6.

Relation between susceptibility and phosphorus content.

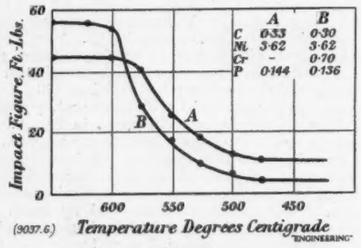


FIG. 7.

Embrittling range for nickel and nickel-chromium steels with high phosphorus content.

amounts of molybdenum varying from nil up to 1·2 per cent. These steels contained manganese 0·14 to 0·31 per cent. and phosphorus 0·022 to 0·040 per cent.

The chromium and nickel-chromium steels without molybdenum were slightly but distinctly susceptible to temper-brittleness, but in every case steels with 0·3 per cent. of molybdenum and over showed no temper-brittleness, *i.e.*, a susceptibility ratio of 1·0, whether quenched from 900 deg. C. or 1,000 deg. C. The biggest difference in the average impact figure between steels cooled in water after tempering and those slowly cooled was within the ordinary limit of variation for any one steel. In an endeavour to obtain a low impact figure from nickel-chromium-molybdenum steels as a result of temper-brittleness, a variety of abnormal treatments were applied to them in cooling from the tempering temperature. For example, some of the hardened and tempered steels were reheated to 600 deg. C. and cooled very slowly, the rate of cooling from 600 deg. C. to 400 deg. C. being 1 deg. in 16 minutes. This treatment had no effect in reducing the impact figure of the steels containing molybdenum. A treatment involving heating for seven days at 450 deg. C, following an extremely slow cooling from 600 deg. C. to 450 deg. C., was no more effective.

Molybdenum does not eliminate, but greatly reduces, the susceptibility of nickel-chromium steels with high phosphorus or manganese content. It is, therefore, desirable to limit these elements to the maxima usual for nickel-chromium steel, though when molybdenum is present the steels remain practically non-susceptible when manganese or phosphorus content is abnormally high. No advantage appears to be gained by adding more than 0·5 per cent. of molybdenum.

DISCUSSION OF RESULTS.

1. Susceptibility to temper-brittleness is shown by the series of experiments described above, and by other work, to be markedly influenced by differences in composition. More extended use of molybdenum is a means, and may prove to be the best method, of overcoming difficulties associated with temper-brittleness.

2. Susceptible steels may, in other respects, be very satisfactory, and after proper treatment may show excellent mechanical properties. Such, for example, are the high-manganese carbon steels, and nickel-chromium steels with relatively high carbon and chromium content. Yet in these steels, air-cooling of fairly large masses from the tempering temperature may often give rise to very low impact figures. The undesirable temper-brittle condition may be avoided by cooling in water from the tempering temperature, but objections have been urged to this procedure on the ground that severe internal stresses are produced. That internal stresses are set up by rapid cooling after tempering is shown by the depression of the elastic limit in water-cooled specimens, and in certain circumstances these stresses may be serious in amount. They might be eliminated if it were possible to adopt water-

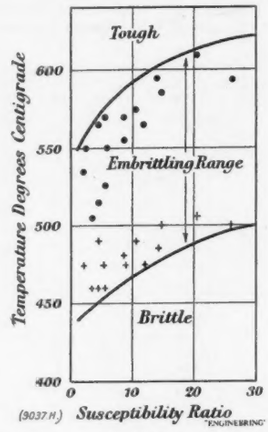


FIG. 8.

Position of the embrittling range.
● Temperature at which there is a 20 per cent. fall in the tough figure.
+ Temperature at which there is a 20 per cent. rise in the brittle figure.

cooling, interrupted at about 400 deg. C. by withdrawal of the steel after it has passed through the embrittling range.

Serious internal stresses may be avoided by the use of a somewhat slower rate of cooling, such as quenching in oil, in which the rate of cooling is considerably checked before the steel cools below 300 deg. C., or they may be relieved without detriment to the properties by reheating to a temperature of 400 deg. C. The impact figure of a steel in the tough condition is not affected by a short treatment at this temperature. To produce a 20 per cent. fall from maximum impact figure in the steel, of which the range is shown in Fig. 1, a treatment for two hours at 450 deg. C. or for 141 days at 350 deg. C. was required.

3. The specific volume of the water-cooled steel is greater than that of the steel slowly cooled from the tempering temperature, but, on heating, shrinkage occurs at temperatures below that at which the impact figure is affected.

4. The diagram, Fig. 8, shows the temperatures of reheating, followed by cooling in water, which produced (*a*) a fall of 20 per cent. in impact figure from the maximum shown by the steel in the tough condition, and (*b*) a rise of 20 per cent. in the impact figure of the steel in the brittle condition. This diagram indicates the position of the embrittling range for all the steels of which the range has been determined in the Research Department, Woolwich. The steels vary in susceptibility from 1·9 to 26·0. It is clear that in a steel showing no temper-brittleness (*i.e.*, susceptibility 1·0) the embrittling range cannot be determined. This may be because it is non-existent, or because it occurs at so low a temperature that the change is suppressed. It is true that low susceptibility is associated with a low range, but there is no indication of a sudden downward tendency which would bring the upper limit of the range in a practically non-susceptible steel to below, say, 500 deg. C. On the other hand, non-susceptible nickel-chromium-molybdenum steels have been found to give the same impact figure after a slow cooling, which involved holding for seven days at 450 deg. C., as in the water-cooled condition. If the range is existent in these steels, its upper limit must be below 450 deg. C. On the whole, it seems that the non-existence of an embrittling range in these steels is more probable than its depression to a low temperature.

For the purpose of restoring the impact figure of a hardened and tempered steel, it is unsafe to reheat a temper-brittle steel at a temperature below 600 deg. C. and rapidly cool, unless the position of the embrittling range is well known. Even after treatment at that temperature there are some steels which may fail to reach 80 per cent. of the maximum impact figure which they are capable of giving without detriment to their tensile properties.

CATALOGUES.

Boiler Compound.—Messrs. J. Dampney and Co., Limited, 87, Bishopsgate, London, E.C. 2, have issued a catalogue and report of tests of their "Apexior" compound for coating boiler plates and all metal surfaces, subjected to heat and moisture, with the object of preventing the adhesion of scale and also stopping pitting and corrosion.

Tools.—A catalogue of tools, appliances and hand-machines, including machines for re-seating valves, boring cylinders, &c., tools for cleaning, expanding, cutting and repairing tubes, and supplies for replacing boiler mountings and pipe joints is to hand from Messrs. W. Crockatt and Sons, Limited, 64, Darnley-street, Glasgow. A priced list is also issued.

Circuit Breakers.—The English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, have sent us a copy of a new revised edition of their catalogue of air-break circuit breakers of the free-handle, laminated-brush type, suitable for use on alternating or direct-current circuits. Complete particulars of sizes and applications are given and prices are stated.

Flexible Shafts.—A catalogue of flexible shafts for instruments, such as speedometers, and for small tools, such as grinding wheels, is to hand from the Westminster Tool and Electric Co., Limited, 116, Putney-Bridge-road, London, S.W. 15. These shafts are of British manufacture and consist of wire closely wound on a thin wire core with four to six windings in opposite helical directions.

Ball and Roller Bearings.—Messrs. Delco-Remy and Hyatt, Limited, 56, Victoria-street, London, S.W. 1, have recently issued a complete set of the catalogue leaves mentioned in these notes at various times, giving tables of dimensions of Hyatt roller bearings and N.D. ball bearings. The leaf last issued deals with the design of tramcar axle boxes and the bearings for the shafts of electric-traction motors.

Conveying Machinery.—A catalogue showing a large variety of conveying, lifting, screening and transmission machinery in parts, units and complete plants is to hand from the Hepburn Conveyor Company, Limited, Wakefield. Several forms of portable and semi-portable belt conveyors are dealt with and also some very large storing apparatus. A separate catalogue of line shafting, bearings, pulleys, toothed gears, &c., accompanies the general catalogue.

Oil-Testing Machines.—A catalogue of oil-testing machines and appliances made by Sir W. H. Bailey and Co., Limited, Salford, Manchester, shows a considerable range of types known from the inventors' names as the Thurston, Ingram and Stapfer, Boult, Bailey, Abel and Redwood types. These appliances cover the tests for the qualities of oil and grease—which are summed up in the catalogue as relating to body, fluidity, coefficient of friction, heat conduction, temperature at which decomposition sets in, resistance to air influence, and non-corrosive effect on metals. The machines are simple and inexpensive. The catalogue is marked price 1*s.*

Steel-Works Plant.—Charging machines for reheating furnaces form the subject of a special catalogue issued by the Wellman Smith Owen Engineering Corporation, Limited, Darlaston. These machines are specially designed in each case and consist essentially of a crane with lifting and travelling or swinging gear with special appliances for gripping and carrying the plates, billets, slabs, &c. Several of the machines are illustrated in operation. The weights handled are not very great, but the conditions of temperature and the need for rapidity in working involve the use of very powerful machinery and call for considerable ingenuity in design.

PHOTOGRAPHIC SURVEYING IN BURMA.—An event of interest during the past year has been the survey, from the air, of the forest reserves in the Irrawaddi Delta in Burma. The work has been carried out under the orders of the Survey of India Authorities, and was in the immediate charge of Major C. G. Lewis, R.E., their expert in the preparation of maps from air photography. Some 1,350 square miles were surveyed at a cost of Rs. 293 per square mile, compared with a cost of at least Rs. 500 per square mile, which would have been necessitated by ground surveying. Although rapidly executed the results have fulfilled expectations. The photos give considerable local detail which could not have been obtained by other means. Main types of forest growth can be distinctly interpreted. Mr. R. C. Kemp, late Chief Inspector of Aircraft to the Government of India, undertook the contract for the air work and photography. Proposals for a continuation of such work next season have been accepted by the Government of Burma.